Gananoque BIODIVERSITY WORKSHOP Proceedings

Introduction:

The Gananoque Biodiversity Workshop was held at the Glenhouse Resort and Training Center, Gananoque, Ontario October 16th- October 18th . This workshop, sponsored in part by the Local Level Indicators Working Group, LLIWG, as a Strategic Initiative of the Model Forest Program. Its purpose was to familiarize participants with the work being done by the Canadian Model Forest Network in terms of biodiversity research, preservation and conservation and to provide an informational basis for the development of future initiatives of the Canadian Model Forest LLIWG.

Any inquiries regarding this workshop, its content or its outcomes can be directed to the Organizing Committee. The organizing committee was: Peter Etheridge- Fundy Model Forest- (506-432-2901, e-mail: etheridge.peter@jdirving.com); Brian Barkley - Eastern Ontario Model Forest- (613-258-8363, e-mail: bbarkley@nrcan.gc.ca); and Mike Waldram- Manitoba Model Forest.-(204-367-5232, e-mail: mikewald@mb.sympatico.ca).This proceedings was compiled by G.R. Kynman.

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Session One:

Individual Model Forests each provided a short presentation outlining; current work and research on, selection, measurement, monitoring of and applications of Indicators of Biodiversity at their local level. After the presentations from the Individual Model Forests a 60 minute plenary discussion occurred for questions, discussion and identification of opportunities for cooperation or identification of potential new Strategic Initiatives and projects that can be considered by the Local Level Indicators Working Group in the development of future work plans.

Western Newfoundland Model Forest - Sean Dolter

Slide 1: Western Newfoundland Model Forest Inc.

NOTES: WNMF Team: Sean Dolter, Jim Taylor, General Manager, George VanDusan, Management Group Corner Brook Pulp and Paper

Slide 2 : Presentation Overview

NOTES: Brief look at our progress on C & I, which leads to the integration of this exercise into Planning for the WNMF, and on-going research of Phase Two,

Slide 3: Criteria and Indicators

NOTES: As a historical reference for Criteria and Indicators, we have in 1992 - 1997 established at working rappour between agencies and have through the IRM process developed a strong set of Goals, Values, and Management Objectives.

Phase Two marked the practical application phase of the Model Forest. We have adopted the CCFM, C & I framework to assist in the preparation of a implementation strategy.

In 1997 - 1998, through a large investment of time by Martin von Mirbach and Len Moores. . . and the C & I Working Group: we have developed a "Rolling Draft" C & I document that includes a fairly comprehensive suite of local level indicators

Presently, we have engaged in Objective Setting Exercise that has (publicly) been completed October 98; the 'Acid' test will follow that will determine the commitment of partnership to practices

Deliverables at the end of this fiscal year will be a SFM C&I report for NF and a Companion document that details LLI gaps, i.e. Wildlife indicators, socio-economic indicators

Develop data paths for indicators

All of which will be up for peer review and evaluation

Slide 4 Criterion 1: Biodiversity

NOTES:To give you some idea of our process for C & I, lets look at two goals developed under Criterion 1: Value: Representative Landscapes

Goal 1.1- Establish protected areas that provide adequate representation of each eco-region Indicators:

Proportion of each eco-region that is in a protected status. (Local/Provincial)

Proportion of each region that is barren, bog, forest and water. (Local/Provincial)

Proportion of each protected area that is barren, bog, forest and water. (Local/Provincial)

Slide 5

NOTES: Objective 1.1.1.

*Establish at least one reserve that is representative of the three ecoregions prior to March 31, 1999. Action 1.1.1.1.

Model Forest facilitate meetings to produce a recommendation to government for

The establishment of an ecological/wildlife reserve(transparent process).

Slide 6

NOTES: And our last look at our C& I process deals with Value: Special Places

Goal 1.2

Establish special management provisions to preserve biologically distinctive or Unique features

Indicators:

Quantitative Indicator:

Proportion of unique features identified in the Natural Areas System Plan that are protected or subject to special management provisions

Descriptive Indicator:

Unique or distinctive biological features. (Local)

Efforts being made to preserve these features (e.g.: legislation, policy, stewardship agreements, special projects). (Local)

Implementation of the Natural Areas Systems Plan. (Provincial)

Slide 7

NOTES:

Objective 1.2.1. To develop a plan to maintain a minimum of 15% of each age class across landscape

Objective 1.2.2. Identify & list biologically distinctive & unique features (through public input) i.e., complete an inventory within the Model Forest

Action 1.2.1.1. Categorize present age classes in terms of successional stages-i.e. regeneration/ immature/mature/overmature.

1.2.1.2 Determine what exists with respect to age class distribution and categorize

1.2.2.1 Have preliminary list before March 1999 by establishing a team of people (researchers/public/community) to conduct and inventory of features and gap assessment (ex. Researcher inventories/students,community group projects that engage communities)

1.2.2.2 Develop management strategies to conserve the unique features

Slide 8

NOTES: To see a critical path in which the WNMF envisions the framework of C & I assisting in the implementation of SFM practices, I submit to you this small schematic flow chart:

Slide 9: On-going Research

NOTES: Now, on to the real stuff This following are projects that the MF partnership is working on currently.

Silviculture Systems - Multi species Study

* Measuring limitations to Habitat Connectivity for Multiple landscape (spatial) scales in commercially harvested landscapes of WNF

* Fluctuations in the distributions and abundance of Cone-dependent Finches (Crossbills: White winged and Red) and Bird Biodiversity in Main River Study Area. Pre-cut baseline -1998 (Montevecchi)

Corner Brook Lake Caribou Study

* evaluate the impacts of harvesting on the demography and behaviour on the CB Lake caribou herd

Structure and Disturbance Dynamics

* Father John McCarthy is examining two contrasting balsam fir ecosystems in WNF. (Main River: small scale gap-phase disturbance and Little Grand Lake: large scale patch mortality - defoliating insects)

Value of Riparian Buffer Strips to Birds in NF

* Ian Warkentin - assess value of buffer strips along waterways (northern water thrush)

Spatial and Temporal Patterns of Forest Fragmentation and Connectivity

* mapping and quantifying current day landscape patterns of Gros Morne, baseline for researchers, indicator of SFM for conservation of biological diversity, application at the for future harvesting blocks - maintaining connectivity

Copper Lakes Buffer Zone Study

* Impact of Forest harvesting on fish habitats; experimentation with Buffer Zone widths; develop indicators (biotic or abiotic) that categorize habitat disturbances and can be applied across a broader scale

Stream Crossing Survey

* impacts of stream crossings on surrounding aquatic habitat

Marten Demographics

* Case Studies

Prey Base Study on the Red Back Vole

* One of the three factors contributing to the recovery of marten population: prey base, habitat and mortality. Literature review on history of introduction of microspecies and dietary implications for marten. Evaluation of small scale introduction, and a workshop debate

C & I of SFM

* As discussed

Slide 10: Silvicultural Systems - Multi species Study

NOTES: Silvicultural Systems - Multi species Study

Researchers from a variety of government, industry and academic institutions are contributing to this long-term project.

Slide 11: Marten Demographics Study, B. Hearn

NOTES: Marten Demographics Study, B. Hearn

This multi-year study has contributed greatly to our understanding of the role that harvesting, landscape fragmentation and habitat loss has played in limiting the numerical increase of marten in NF

Slide 12: Applied Research

NOTES: Pine Marten Research enabled discussions on the proposed Pine Marten reserve to center around the habitat needs of this endangered species

Slide 13: Future Endeavours

NOTES: Pilot national inventory system

* that will provide monitoring information for climate change, C & I, biodiversity, and sustainable development. This new national inventory design will be piloted for the Model Forest area

Focus of effective use of RS/GIS that support SFM

Refine monitoring/data capture - LLI's

Continue to refine and develop processes for determining RTE species in NF; knowledge of natural processes

Develop cutting practices that (attempts to) mimic natural ecosystem disturbances

Support of Long-term Research into defining the indicators of SFM

Assist implementation through managing partners

Transfer of technical and process knowledge

Evaluation des systèmes de gestion durable de la Forêt modèle du Bas-Saint-Laurent : indicators de biodiversité

Pierre BELLEAU, Coordonnateur de la recherche et du suivi, Forêt modèle du Bas-Saint-Laurent,
284 rue Potvin, Rimouski, G5L 2L5, fmodbsl@globetrotter.net

Introduction

À l'instar des autres Forêts modèles au Canada, le mandat confié en phase II à la Forêt modèle du Bas-Saint-Laurent passe par l'élaboration, le développement et la mesure d'indicateurs locaux permettant de vérifier l'atteinte des objectifs de gestion forestière durable. L'exercice prend naissance dans les critères et indicators suggérés par le Conseil canadien des ministres des forêts (CCMF) dans l'ouvrage intitulé : "Définir la gestion durable des forêts".

Bien que le concept de biodiversité soit peu nouveau, il anime de fréquents débats sur la scène forestière actuellement principalement à cause d'un intérêt marqué pour tout ce qui traite de certification environnementale.

Nous expliquerons ici brièvement ce que la Forêt modèle du Bas-Saint-Laurent compte réaliser en matière d'évaluation du maintien de la biodiversité par le biais d'indicateurs dans les mois et les années à venir.

Les indicateurs du CCMF

La conservation de la diversité biologique vient en tête de liste des critères écologiques qui sont proposés par le CCMF. On subdivise ce même critère en trois catégories (sous-critères) : les écosystèmes, les espèces et la génétique. Pour débuter la mise sur pied de son programme de surveillance, la Forêt modèle du Bas-Saint-Laurent joint à sa liste la plupart des indicateurs du CCMF, qu'elle conservera jusqu'à ce que des indicateurs plus performants puissent être identifiés, s'il y a lieu. La liste d'indicateurs fera l'objet de fréquentes révisions.

Diversité des écosystèmes

Superficie des types forestiers et le pourcentage de leur superficie relativement aux conditions prévalant depuis de nombreuses années et à la superficie forestière totale.
Le pourcentage de la superficie et la superficie de chaque type forestier et classe d'âge.
Le degré de fragmentation de l'écosystème forestier et de connexion entre les éléments de l'écosystème.

Diversité des espèces

Le nombre d'espèces connues dépendant de la forêt et classées comme éteintes, menacées, menacées d'extinction, rares ou vulnérables, relativement au nombre total des espèces connues dépendant de la forêt.

Indicateurs complémentaires

Au Québec, de nombreux efforts de développement dans le domaine de la biodiversité sont dirigés vers l'identification d'indices permettant d'orienter les opérations forestières en accord avec le maintien d'un degré acceptable de diversité. Une analyse rapide nous permet de distinguer deux grandes écoles de pensée mais aucune ne rallieraient pour l'instant tous les intervenants :

Indice de diversité forestière
Indice global de qualité de l'habitat (IQH)

Le première approche, élaborée pour de grands territoires comme ceux du domaine public, suggère de conserver au sein de la végétation en milieu forestier, un assemblage de différentes classes d'âge. Quoique d'application fort simple on doit cependant déplorer l'absence de règles minimales concernant la distribution sur le terrain de ces mêmes classes d'âge.

La seconde est plus complexe. Elle appelle en série plusieurs IQH relatifs à différentes espèces animales,

représentatives d'une guilde ou importantes d'un point de vue économique. La résultante : une valeur globale reflétant la qualité des habitats d'un milieu pour la faune mais dont l'interprétation reste risquée.

Il y a donc lieu de poursuivre le développement d'indicateurs dans le contexte de la Forêt modèle pour cibler une approche plus efficiente.

Les plans d'aménagement

Pour les besoins de la Forêt modèle du Bas-Saint-Laurent, des indicateurs qui permettent de visualiser au fil des ans les progrès réalisés sont jugés nettement préférables. Par ailleurs, pour s'assurer que les produits développés soient transférables dans la réalité, les coûts associés à la mesure des indicateurs doivent demeurer à l'intérieur de certaines limites raisonnables.

En ce sens, on sélectionnera davantage des indicateurs dont la relation avec le paramètre suivi est dite indirecte. Bien que certains auteurs proposent de recenser la population des espèces dites communes ou mêmes rares, ces procédés sont peu applicables dans la réalité vu les coûts et les problèmes logistiques qu'ils amènent.

L'existence de zones d'affectation dans les plans de protection et d'aménagement, pour lesquelles des modalités d'intervention et autres directives ont été édictées, ouvre la voie sur de nouveaux indicateurs de diversité.

À titre d'exemple, en favorisant l'établissement de peuplements dont la composition finale est en accord avec les caractéristiques écologiques du site, on favorise la diversité des écosystèmes forestiers dans le respect du potentiel du milieu. Les caractéristiques écologiques sont à l'origine de la notion de série évolutive que l'on désigne aussi par type écologique ou encore végétation potentielle. Le plan d'aménagement prévoit la protection intégrale des écosystèmes rares auxquels il va sans dire les dispositions précitées ne s'appliquent pas.

De plus, en prenant les moyens nécessaires pour accroître la proportion des sites régénérés de façon naturelle plutôt que d'opter pour la plantation, on contribue partiellement à conserver une diversité génétique.

C'est par le suivi de telles variables indicatrices, avec le support de la géomatique et la mise à jour périodique des couches localisant les travaux sylvicoles, que la Forêt modèle du Bas-Saint-Laurent compte principalement s'attaquer au problème du monitorage de la biodiversité.

Matières à développement

Un des objectifs qu'il est permis de se fixer dans le domaine des indicateurs du maintien de la biodiversité est le développement d'indicateurs globaux, qui satisferaient l'ensemble des catégories de diversité.

La Forêt modèle du Bas-Saint-Laurent participe depuis quelques années à la réalisation d'une étude visant à bâtir un modèle de prédiction de la diversité des communautés aviaires. Ce projet avant-gardiste est mené par un chercheur du Service canadien de la faune. À partir d'images satellites (Landsat TM), l'approche consiste à créer de nouveaux types forestiers en se basant sur certains facteurs décrivant le couvert arborescent et qui sont perceptibles par les oiseaux. Le modèle illustre enfin au moyen de cartes, le potentiel de diversité aviaire sur un territoire donné. On évalue actuellement les performances de cet outil en confrontant ses prédictions à celles effectuées par une dizaine d'experts en ornithologie.

Une autre étude est en développement. Elle pourrait faire entrer en scène des chercheurs de la faculté de foresterie et de géomatique de l'Université Laval et du département de gestion de la faune de l'Université du Québec à Rimouski.

Le premier postulat du raisonnement, plutôt trivial à première vue, est qu'il existe un lien étroit entre la nature du couvert végétal et les communautés qu'il abrite. Le second est que les processus présents dans la nature devraient permettre de rassembler les conditions propices pour soutenir localement le potentiel de biodiversité. Chaque espèce tant végétale qu'animale occupe une niche spécifique, de sorte qu'on peut penser maximiser la diversité et l'abondance de chacune d'elle en diversifiant le couvert forestier.

Mais cette diversification ne peut se soustraire à un certain ordre qu'impose d'abord les caractéristiques

écologiques (végétation potentielle) du milieu dont il a été précédemment question. Cette composante de la mosaïque forestière est donc prédéterminée si on a le souci de la respecter. En second lieu, la proportion des différentes classes d'âge est elle aussi réglée à priori puisque conséquente au désir de maintenir un rendement soutenu en matière ligneuse. Dans cette équation il reste encore quelques paramètres qui appellent un certaine forme d'organisation :

L'arrangement spatial
La dimension
Le degré de connexion
Les stades de développement

Le projet consistera à définir un patron de végétation offrant les conditions les plus favorables à la biodiversité. Il prendra la forme d'un ensemble de spécifications bien plus que d'une représentation statique de la forêt. Pour définir ce patron on aura recours à différents procédés qui serviront à décrire le régime naturel des perturbations et la composition des forêts à l'époque précédant la colonisation (back-tracking). L'indicateur global de diversité deviendra le degré d'atteinte ou de conformité avec cette gamme de conditions. Il sera calculé en analysant la répartition des polygones sur les cartes écoforestières.

Une étape de validation sera incontournable. On combinera à cet effet une démonstration théorique fondée sur l'état actuel des connaissances que viendront appuyés des relevés effectués sur le terrain.

Perspectives de la Forêt modèle Crie de Waswanipi sur la biodiversité

Présenté par :
Steve Morel, ing.f., M.Sc.
Responsable forestier

Introduction

La Forêt modèle Crie de Waswanipi (FMCW) fait partie depuis septembre 1997 du réseau canadien de Forêts modèles. Son ajout vise à combler un vide au niveau du développement d'approches d'aménagement forestier durable dans la perspective autochtone. Sa vision est de :

Maintenir et améliorer la qualité du territoire de l'Eeyou Astchee pour le bénéfice des autochtones et des autres utilisateurs. Il s'agit notamment d'assurer le développement économique, social et culturel de la première nation crie de Waswanipi et des autres utilisateurs.»

La FMCW est présentement en phase de mise en place. Il n'y a pas à l'heure actuelle de travaux portant sur la biodiversité. Cette présentation s'attardera donc davantage aux perspectives de la FMCW sur la biodiversité et aux questions auxquelles elle tentera de répondre plutôt qu'aux réponses qui viendront par la réalisation de projets de recherche et développement.

Comités de travail de la FMCW

Des comités de travail vont être formés prochainement afin de rendre opérationnelle la vision de la Forêt modèle Crie de Waswanipi. Les comités seront formés de Cris, d'experts des domaine concernés et de partenaires de la FMCW. Ils suggéreront des projets pouvant répondre aux buts de la FMCW. Plusieurs sujets touchant la biodiversité seront abordés par les comités de travail. Il s'agit notamment de :

l'évaluation des pratiques forestière à Waswanipi;
l'évaluation de la stratégie d'aménagement par forêt mosaïque;
l'analyse de la qualité requise du milieu pour répondre aux besoins en espèces fauniques et végétales d'intérêt pour les Cris;
développer des critères et indicateurs de la viabilité des terrains de piégeage;
l'utilisation des connaissances écologiques des Cris.

La stratégie d'aménagement par forêt mosaïque

La communauté de Waswanipi est impliquée dans les activités d'aménagement forestier depuis le début des années 1980. Le territoire sous-contrôle d'aménagement par la communauté était initialement exploité en suivant le modèle des compagnies forestière situées dans les alentours. Les coupes étaient de grande superficie et tenaient peu compte des besoins des chasseurs et trappeurs de la communauté.

Face au mécontentement d'une partie de la population concernant les pratiques forestières, une approche d'aménagement par forêt mosaïque a été mise en place dans les forêts de Waswanipi. Plusieurs industriels forestiers ont également mis en place cette approche afin répondre aux besoins des Cris qui pratiquent leur mode de vie en territoire.

Cette approche consiste à préserver, à l'échelle locale, des forêts résiduelles équivalentes ou supérieures aux superficies de coupe. Pour ce qui est de Waswanipi, l'approche s'apparente à un système par trois passes. Les coupes ont habituellement une dizaine d'hectares (maximum de 40 ha). La mosaïque appliquée sur le terrain consiste à récolter le tiers de la superficie forestière productive des secteurs d'intervention (figure 1), un second tiers pouvant être récolté 30 ans plus tard et le dernier tiers un autre 30 ans plus tard.

Figure 1. Exemple d'un secteur d'intervention coupé
selon l'approche de forêt mosaïque

Bloc 1
20 hectares
Récolte en 1990

Bloc 2
20 hectares
Récolte en 2020

Bloc 3
20 hectares
Récolte en 2060

Les coupes forestières se retrouvent toujours en position sous-dominante sur le territoire comparativement aux forêts jeunes et matures qui servent respectivement de couverts de nourriture et d'abris pour la faune. Cette approche répond davantage aux besoins, à l'échelle locale, de la communauté. La mosaïque peut permettre d'améliorer la qualité de l'habitat de plusieurs espèces fauniques d'intérêt pour les Cris comme l'orignal, le castor et le lièvre tout en maintenant un habitat adéquat pour la martre qui préfère les peuplements résineux matures.

Le paysage forestier naturel de cette région est dominé par de vastes étendues de forêts uniformes. Les peuplements sont de structure équienne et dominés par l'épinette noire. Ces forêts se régénèrent habituellement par des feux qui peuvent avoir de grandes superficies. L'approche mosaïque constitue un changement important par rapport à la dynamique naturelle de cette forêt. Ses impacts sur la biodiversité méritent d'être analysés. Les

questions suivantes se posent :

Quels sont les impacts sur les habitats des espèces de forêts profondes ?
S'agit-il de fragmentation ?
Quels sont les impacts sur la biodiversité ?
L'application systématique de la mosaïque forestière amène-t-elle un déséquilibre écologique par rapport au régime des perturbations naturelles (feux) ?

La recherche dans la Forêt modèle Crie de Waswanipi

La Forêt modèle Crie de Waswanipi est une expérience d'aménagement à grande échelle à l'intérieur de laquelle la recherche est appelée à jouer un rôle important. Deux de ces axes de recherche abordent la question de la biodiversité :

Évaluer la stratégie d'aménagement en forêt mosaïque mise en place à Waswanipi selon les critères et indicateurs d'aménagement forestier durable retenus;
fournir les connaissances socioécologiques nécessaires à une gestion écosystémique des territoires de trappe ainsi que les outils de gestion requis.

Liens entre les besoins des autochtones et la préservation de la biodiversité

L'établissement de stratégies d'aménagement répondant aux besoins des autochtones devrait grandement contribuer au maintien de la biodiversité. Une variété d'écosystèmes doit être maintenue afin d'y arriver puisque les autochtones utilisent un large éventail de ressources en territoire. Il peut s'agir de faune, de plantes médicinales, de matériaux de construction et autres. Les autochtones qui vivent en forêt boréale exercent fréquement leur mode de vie à partir de territoires de chasse familiaux qui sont de l'ordre de quelques centaines de kilomètres carrés. L'approche du filtre brut peut être appliquée afin de maintenir l'ensemble des écosystèmes à cette échelle alors que le filtre fin peut permettre de préserver les sites qui ont une valeure particulière et les habitats fauniques critiques. Des habitats fauniques de qualité pour les espèces exploitées par les autochtones doivent se retrouver à l'intérieur de chaque terrain de pégeage. L'approche du filtre brute est compatible à la préservation de l'habitat de ces espèces (martre, orignal, castor, ...) puisqu'elles utilisent une vaste gamme d'habitats (forêts jeunes, forêts vieilles, milieux riverains, peuplements résineux, mélangés, feuillus, ...).

Contributions de la FMCW au développement de critères et indicateurs locaux de biodiversité

La Forêt modèle Crie de Waswanipi peut apporter des contributions intéressantes au niveau du développement des critères et indicateurs d'aménagement forestier durable. Elle peut notamment développer des méthodes afin d'utiliser les connaissances écologiques des autochtones lors du développement des indicateurs. Elle peut également permettre de faire le lien entre les indicateurs de biodiversité et ceux touchant la viabilité des territoires de chasse familiaux.

Eastern Ontario Model Forest; Indicators for the Conservation of Biodiversity

Cathy Nielsen, Forest Biodiversity Specialist, Science and Technology Transfer Unit
OMNR, Kemptville

The EOMF Criteria and Indicators Project is being developed and implemented under the direction of

the EOMF Science Committee. Martin Von Mirbach and Lorne Johnson have been contracted to facilitate the implementation of the project.

Before addressing indicators for the conservation of biodiversity directly, background information about Criteria and Indicators in the Eastern Ontario Model Forest will provide a context. Challenges that the EOMF must address in the development and application of Criteria and indicators include; private land ownership of 88 percent of the landbase and hence many managers of relatively small woodlots; over one million people with diverse values; a high level of fragmentation and human disturbance of forests; lack of management authority of the EOMF who is restricted to a model of influence and finally the transition in roles in resource management as the provincial government withdraws from some traditional activities which means that at this time there is no current forest resource inventory.

Given this context the EOMF has identified the following objectives for the use of indicators:

1. prepare state of the forest report
2. use as a framework for the evaluation and adjustment of the EOMF program
3. use as communication tool to deliver sustainable forest management message at the eastern Ontario "forest community" and the public
4. provide a decision support and performance monitoring tool for forest managers

Focusing on the indicators selected under the Biodiversity Criteria, the following values were identified by consultation with a focus group:

1. conserve diversity of ecosystems
2. wildlife habitat
3. recognize all elements
4. recognize dynamic nature of ecosystems

In selecting indicators the EOMF has taken a very pragmatic approach. A "starter set" of indicators has been selected based on relavancy and the EOMF's ability to report on the indicators by March, 1999. The indicators address several scales with several being reported across the EOMF while stand level indicators will be reported on a case study basis. An additional set of future indicators has also been developed and will be refined and checked for data availability over the next year.

Starter Set - Across EOMF

-percent forest cover
-amount and percent forest interior
-number forest dependent species listed as VTE
-population level changes of selected species

Starter Set- Stand Level Case Study

The following stand level check list was developed by Dr. Paul Keddy and Chris Drummond from the University of Ottawa, as part of an EOMF project. The document "Ecological Properties for the Evaluation of Eastern Ontario Forest Ecosystems" is available as EOMF Information Report No. 13. The checklist provides thresholds for the characteristics listed below. The characteristics and thresholds are based on documentation of characteristics of relatively undisturbed forests that are similar to forest types of eastern Ontario.

-tree size
-canopy composition
-coarse woody debris
-number of wildlife trees
-number of speeies on list for herbaceous layer, mosses, lichens, liver worts, birds, carnivores

'The Future Set of Indicators include the starter set above and the following:
Ecosystem Diversity:

-percent forest cover and composition relative to historical condition
-age class distribution
-fragmentation index
-area of forest protected
-interior forest area

Species:

-forest dependent VTE species and changes in status
-population levels for selected species
-species occupying only a portion of former range
-area colonized by exotics
-amount of habitat enhancement work ongoing

Genetic:

-proportion of area in plantations
-genetic concerns addressed in silvicultural practices i.e. seed zones

The document " Local Level Indicators for the EOMF" ineludes a comprehensive irnplementation plan with many steps, however, the most immediate needs are:

1. Amalgarnation and analysis of data for "Starter set " of indicators
2. Further refinement and data acquisition for ".Future Set"
3. Communication- Education - need to demonstrate the role that criteria and indicators can play in reaching sustainable forestry goals in the forests of eastern Ontario.

Biodiversity Indicators Work at the Lake Abitibi Model Forest

Chris Wedeles, LAMF Indicators Consultant

Keywords: indicators, Forest Ecosystem Science Cooperative, Lake Abitibi Model Forest, screening, field test

Abstract

Work related to indicators of biodiversity conservation at the Lake Abitibi Model Forest is embedded in a broader effort directed at screening and testing indicators of Sustainable Forest Management. The Model Forest is one of three partners working on this effort under the auspices of the Forest Ecosystem Science Co-operative. The project is presently in the second of three planned phases. In the first phase, a large list of candidate indicators was pared down to a more reasonable number using a screening framework which evaluated each of the candidate indicators against a suite of desirable indicator qualities. In the second phase the remaining indicators are being tested at two study sites, one of which is the Lake Abitibi Model Forest. The third phase will examine research needs associated with the indicators. This paper reports on the screening framework and some of the considerations regarding the biodiversity indicators which have arisen during the field tests. One of the key successes of this project to date is in showing that a cooperative approach among industry, the Model Forests, and government to addressing topics of common interest is highly practical.

Background

Work related to indicators of biodiversity conservation at the Lake Abitibi Model Forest is embedded in a broader effort directed at screening and testing indicators of Sustainable Forest Management. The Model Forest is one of three funding partners for this work, which is proceeding under the auspices of the Forest Ecosystem Science Co-operative (see box).

The project is currently in the second of three phases. In the first phase, a large list of potential indicators of sustainable forest management was screened, and pared down to a reasonable number. The second phase consists of field-testing the screened indicators, and the third phase will involve defining and exploring research needs which have arisen during the course of the project.

Phase I - Indicator Screening

Prior to the project beginning, the Co-op convened a series of three workshops to identify possible indicators of sustainable forest management. The workshops identified 152 possible indicators. The first phase of the project involved developing a screening framework, and applying the framework to identify those indicators with potential value in assessing the state-of-the-forest and the sustainability of forest management.

The framework contained eleven key qualities of indicators each with a relative weight. (Table 1). Each indicator was then evaluated against all eleven qualities and scored using the relative weightings. Four qualities were thought to be so important that any one of them could be the basis for rejecting an indicator. If an indicator did not satisfy any of these four qualities they were eliminated from further consideration. These critical qualities were: Relevance to Criterion, Sensitivity to Change, Measurability, and Predictability.

The six CCFM criteria provided a basis for grouping the indicators under consideration.

The Forest Co-op is a partnership of industry, government, research institutes, and other organizations concerned with forest ecosystems. The primary goal of the Forest Co-op is to facilitate collaborative research and inter-disciplinary ventures. The Co-op's members include most of the large forest products companies in Ontario, several branches and science and technology units of the Ontario Ministry of Natural Resources, the Canadian Forest Service Research Facility at Sault Ste. Marie, Saskatchewan Environment and Research Management, and several academic institutions. Co-op partners can "team up" to fund projects of mutual interest. The indicators project which is discussed here was funded by the Ontario Ministry of Natural Resources, E.B. Eddy Forest Products Ltd., and the Lake Abitibi Model Forest.

As a result of applying the screening framework, 59 of the original 152 indicators were retained, 47 were rejected, and the remainder were considered to redundant with one or more of the retained indicators (35), or were allocated for further research (12) because they were poorly understood or their potential for use as indicators was unclear.

Table 1. Qualities used to screen potential indicators.

Quality	Weight	Explanation
Relevance to Criterion	18	Indicators must be related to the criterion which they are attempting to portray
Measurability	16	The indicator must lend itself to quantification using readily available technology
Predictability	13	The future value of an indicator must be predictable in order for it to be of use in an adaptive management context
Communicability/Clarity	11	Indicators should be understandable by members of the informed public who are involved in forest management decision making
Practicality	11	The cost to obtain indicator data must not be unreasonable
Response Oriented	7	Indicators which are response oriented (i.e. which measure the response of the forest to an action), are of greater value than indicators which measure the management actions taken.
Sensitivity to Change	6	Indicators must respond to environmental, social, or economic changes
Data Availability	6	Indicators which use data already being collected should be recognized for their utility
Simplicity	5	Indicators for which data are easy to collect, analyze and interpret are favoured.
Comparability to Thresholds	4	An indicator is not helpful if increases or decreases in value are not clearly related to desirable values
Ability to Provide Early Warning	3	Indicators which provide an early warning of undesirable changes should be recognized for their utility.

Of 21 original indicators relating to biodiversity conservation, 12 remain under consideration.

Phase II - Field Tests

This summer, field tests of the indicators are being carried out at two study sites - the Spanish Forest in central Ontario, and the Iroquois Falls Forest in north-eastern Ontario. (A basic premise of the project was that indicators were to be useful and applicable at the management unit scale.) These study sites present interesting contrasts for several reasons. The Spanish Forest contains both Great Lakes-St. Lawrence and Boreal forest types, and so the breadth of biodiversity concerns is greater than in the Iroquois Falls Forest which is dominated by lowland black-spruce boreal forest. The Spanish Forest falls under the management domain of four different Ontario Ministry of Natural Resource (OMNR) districts, which makes information gathering much more complex than in the Iroquois Falls forest, which is entirely within one OMNR district. Finally the data management infrastructures are very different in the two forests, providing insight into a range of data assimilation and analytical issues. The indicators being tested, and some preliminary findings or considerations are described in Table 2

Table 2. Some preliminary findings and considerations regarding the biodiversity indicators being tests at two study sites.

Indicator	Notes
Percent and extent of area by forest type and age class	Taken from CSA/CCFM suite of indicators, this is intended to show how the forest changes over time. Both study sites have this information well in hand as it's crucial for basic forest management.
Area, percentage and representativeness of forest types in protected areas	Most of this information is available from both study sites, however, we are finding that the management unit is too small an area to deal with issues related to representativeness.
Level of fragmentation and connectedness of forest ecosystem components	The analysis for this indicator is being done using an OMNR developed model (Patch Analyst) which encapsulates portions of FRAGSTATS to calculate indices of fragmentation, connectedness, etc.
Frequency distribution of clearcuts	This indicator is intended to be used to compare the size distribution of man-made disturbances (clearcuts) to those of natural disturbances (primarily wildfire).
Shape of harvest blocks	Similar to above indicator, the idea for this indicator is to compare the shape of harvest blocks to the shape of burnt patches
Number of forest dependent species classified as extinct, endangered, threatened, rare, or vulnerable	We are using the COSEWIC list, and the Ontario analogue (COSSARO Committee on the Status of Species at Risk in Ontario)as the basis for defining RTE species.
Population levels of RTE species	For the two study sites, the only RTE species are eastern cougar, woodland caribou, bald eagle, and peregrine falcon. Population surveys and censuses generally do not exist, but some bases for making estimates are available.
Population levels of selected species	The OMNR has published a list of more than 50 species recommended as indicator species. We are using this list as a starting point, and are attempting to derive population levels, or indices for as many as possible.
Habitat quality and quantity of selected species	The Ontario wood supply model SFMM (Strategic Forest Management Model) produces matrices of wildlife habitat quality for many species - this matrix will be used to calculate values for this indicator.
Adherence to seed zones	Company records of seed source is being used for this indicator.
Size of parent population of natural regeneration	This is a research indicator - we will investigate the validity of this indicator, and means to develop a value for it.
Number and distribution of individuals relative to Minimum Viable Population for sub-populations of concern.	This indicator, and the Minimum Viable Population (MVP) notion is used to attempt to address the issue of genetic diversity beyond application simply to crop trees.

We anticipate completing Phase 2 before the end of 1998. One of the key successes of this project to date is in showing that a cooperative approach among industry, the Model Forests, and government to addressing topics of common interest is highly practical.

Development and Application of Indicators of Biodiversity in the Manitoba Model Forest

Mike Waldram, Manitoba Model Forest: Greg Wickware, GeoSpatial International, Burlington, Ont

Key Words : biodiversity, indicators, forest plan, natural disturbance

Introduction

Between 1992 and 1997 - Phase I of the Model Forest Program, the Manitoba Model Forest was largely involved in baseline data collection, habitat model development and partnership building. Now in Phase II much of our program revolves around sustainable forest management indicator development using information and models developed in Phase I. Although we still have a long way to go relative to data collection, research and model development we have decided to produce an initial suite of indicators for all 6 of the Canadian Council of Forest Ministers criteria for Sustainable Forest Management (SFM) based on existing information. We fully expect that our initial suite of indicators will change over time as more information is obtained, research completed and models tested. A number of initiatives are currently underway that will influence future indicator development and are discussed here as well as our more immediate indicator development process and results.

Indicator Determination Process and Approach

At about the same time that the Model Forest program set as one of its national objectives " to establish indicators of Sustainable Forest Management including measurement and monitoring systems.....", the major industrial partner in the Manitoba Model Forest, Pine Falls Paper Co., was beginning the process of determining how to approach the development of a ten year forest plan to cover the period 2000 to 2010. PFPC was also interested in positioning themselves for certification under the CSA process. After a number of discussions in the Model Forest Advisory Group and with the Board of Directors it was decided to directly link the Model Forest Indicator program to the Pine Falls Paper Forest Plan.

Based on the three dimensions of sustainability; ecological, social and economic the 10 year plan will include three major themes:

- Sustain the long-term health and diversity of the Forest Management Licences forest ecosystems;
- Reflect public values and goals for the FML as determined through an on-going public consultation program; and
- Ensure the continuing viability of the Company's forest products operations including flexibility for its future growth.

It is proposed that the Ten Year Plan will be prepared within the context and framework of SFM using the Canadian Council of Forest Ministers Criteria and Indicators approach. The plan will be structured in such a manner that ensures all elements of C & I are covered, and in a sequence that ensures public values, and those of the company, are driving the strategies which become the foundation for the Plan. A discussion paper detailing the approach and proposed structure of the plan will be released to the public in the fall of 1998 and will also be available for review and comment on the Web Site of the Manitoba Model Forest.

The plan development process began with a Model Forest sponsored Workshop held in Winnipeg in April 1998. The objectives of the Workshop included developing a preliminary framework of values to guide the development of C & I. . Fifty participants from many different organizations and communities provided input on public values for each of the 22 elements outlined in the CCFM Criteria and Indicators. The Manitoba Model Forest was supported by the Local Level Indicators Strategic Initiative through additional funding which allowed us to bring in outside expertise from Western Newfoundland Model Forest and Fundy Model Forest.

This Model Forest sponsored workshop was followed up with additional values exercises using a standing Sustainable Forest Management Advisory Committee sponsored and chaired by Pine Falls Paper Co. A number

of Model Forest partners sit on this committee and the Model Forest itself is represented.

This initial set of values were then organized within each criteria and element and then draft goals were developed for each of the values. An initial suite of indicators was then developed by a smaller group for each of the goals. Measurable indicator levels or targets were then drafted for each of the indicators. Finally, forest management strategies and operating procedures were established to achieve the desired results. This process is continuing with additions and changes expected after further review by and consultation with local communities, focus groups of scientists and academics, PFPC's Advisory Committee, and input from public open houses, a 1-800 phone number and an internet web site.

Preliminary Indicators for Conservation of Biodiversity

An initial suite of indicators have been developed for all 6 Criteria and will be available for review from the Manitoba Model Forest and PFPC in the fall of 1998. The initial suite of indicators developed for the CCFM's first criteria - Conservation of Biological Diversity are presented here as an attachment to this paper and are organized within the framework of 1) Criterion 2) Element/Value 3) Goals 4) Indicators 5) Indicator Level both current and target and 6) Forest Management Strategy both current practice and proposed. It is fully expected that goals, indicators, targets and strategies will change not only as a result of further input and review but also as a result of testing, analysis and scenario planning through the use of computer models.

Related On-going Research and Activities

There are a number of research programs and projects occurring in which the Manitoba Model Forest is a lead proponent or part of a larger partnership that once completed will provide additional information and tools to the Biodiversity Indicator program. Two of these projects are only minimally outlined here. Complete information about these projects and others can be obtained from the offices of the Manitoba Model Forest.

Bench Marking Genetic Diversity in Black Spruce

This is a two year study being conducted by Om P. Rajora of the University of Alberta. Funding for the project has been provided through a partnership of the Manitoba Model Forest, Pine Falls Paper Co., Manitoba Natural Resources and Tolko, Manitoba. The objectives of the project are:

To determine the genetic diversity inherent in natural fire-origin, post-logged naturally regenerated and post-logged planted stands of black spruce.

To compare the effects of forest management practices of harvesting, natural and artificial regeneration and forest fires on genetic diversity of black spruce.

To determine genetically sustainable practices and develop genetic biodiversity indicators.

Design, Implementation and Monitoring of Timber Harvesting Practices that Approximate Wildfire Disturbance

Given our limited understanding of ecological processes, many have argued that we have the greatest chance of maintaining biodiversity and forest health if the design of timber harvesting mimics the patterns of a regions natural disturbance regime. In the Manitoba Model Forest wildfire is the dominant type of stand-replacing natural disturbance with at least 75% of the area burned at least once within the past 115 years. This 4 year project will determine the pattern of arrangement, in terms of residual patches on a harvested landscape, needed in a harvest area to best emulate a natural disturbance and how much structure (residual trees, snags, downed woody material) should be left in a harvest block in order to best emulate a natural disturbance. A trial harvest with follow-up monitoring program will be conducted during the winter of 1998/99. Finally a manual of Natural Disturbance Operations Guidelines taking into account both harvesting and renewal considerations will be developed.

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Local Level Indicators for the Prince Albert Model Forest

Dwayne Dye

KEY WORDS: Prince Albert Model Forest, Local level indicators, aquatic indicators, soils, landscape management, socioeconomic

ABSTRACT:

The Prince Albert Model Forest, PAMF, is initiating projects to examine indicators for monitoring the effects of forest management activities on aquatic and hydrological systems, soils and landscape structure. The PAMF is also investigating indicators associated with monitoring the socioeconomic aspects of forest management activities and developments.

Summary:

The Local Level Indicators Working group (LLIWG) for the PAMF has embarked on developing a set of criteria and indicators (C&I) for the monitoring of sustainable forest management in the PAMF. During the 1997-98 fiscal year, a study was carried out under contract to formulate a list of criteria and indicators specific to the PAMF's needs. The project resulted in a robust list of indicators based on the CCFM C&I tempered by the needs of the partners. There is a need to review this list to develop a suite of indicators that can be implemented/monitoredby the PAMF taking budgetary constraints into consideration.

For the 1998-99 fiscal year $55,000 has been allocated to the development and implementation of a set of C&I. The budget is being distributed as follows.

1. Aquatic C&I Development: the partners, after careful review, identified a common gap in the C&I, with respect to aquatics. A project has been developed in partnership with Ecosystem Health Working Group and the Foothills Model Forest to have a literature review done of aquatic health indicators along with a synthesis of the information and a set of recommendations on how to monitor the indicators in the field. The intent from the PAMF'S point of view, is to develop a set of key indicators to monitor water quality and quantity as well as aquatic biota and to develop a plan to implement them. Monitoring would begin in the year 1999-2000. The initial budget allocation for this project is $15,000.

2. Socio-Economic C&I Development: because of the unique makeup of the partnership, the PAMF has been asked to concentrate efforts on the development of socioeconomic C&I. The plans for 1998-99 include putting on a workshop involving CFS personnel and others to aid in the development of a set of socioeconomic C&I and to guide the implementation of these C&I. It is hoped that is workshop will be national in scope and involve the other model forest. It will be held in early fall. This workshop would lead to a project to develop a list of socioeconomic C&I and an implementation plan for them applicable to the PAMF. A budget allocation of $5,000

has been set for this undertaking.

Also, along these lines the PAMFA is investigating a project to develop C&I for monitoring public consultation / involvement. There is a question as to how much public consultation / involvement is enough and how much is too much. The concern is also tied to the fact that public consultation / involvement requires a large dollar investment and there is a need to know how to effectively and efficiently use the money allocated to it. The contract to carry out the project is currently being developed and is targeted at $20,000.

3. Refine a list of C&I for the PAMF: there is a need to develop a list of C&I specific to the PAMF and an implementation plan for the 1999-2000 fiscal year. Tolerances and /or targets need to be set for the identified indicators. This project will be carried out under contract and will be undertaken in the fall, following the workshop on socioeconomic indicators. A budget allocation of $15,000 has been made for this project.

4. The Ecosystem Health Working Group is also investigating a project to look at the effects of forest management activities on the soils in the area. Soil compaction and displacement is of the greatest concern. The project will develop indicators for modelling this and develop a protocol for implementation in the field. A budget allocation of $20,000 has been set aside for this project.

5. The Ecosystem Health Working Group is also setting up a workshop early in the new year to investigate the management of landscape structure. the intent of forest management activities in the boreal forest is to emulate the impact of natural disturbances, in Saskatchewan's case, the effects of wildfire. The approach to assessing the effects of fire on landscape structure is relatively new, but there is a need to understand it. The workshop will involve some leaders in this field and will result in a strategy for assessing the impacts of wildfire on the Saskatchewan boreal forest landscape and how to apply forest management activities to emulate these effects and how to monitor landscape structure. A budget allocation of $15,000 has been made for this project.

The 1998-99 year will be spent on developing a list of indicators and an implementation plan for them. It is expected that implementation will begin in 1999-2000.

Foothills Model Forest

Daniel Farr

Foothills Model Forest is a unique community of partners dedicated to providing practical solutions for stewardship and sustainability of our forest lands. At 27,500 square kilometres, Foothills Model Forest is the largest Model Forest in the world. It includes all of Jasper National Park, Willmore Wilderness Park, and several provincial forest management units including Weldwood's Forest Management Agreement area. The communities of Hinton and Jasper are within the model forest.

In 1997/98, Foothills Model Forest supported several initiatives related to biodiversity, the Cumulative Effects project, the Grizzly Bear project, the Local Level Indicators of Sustainable Forest Management project, the Biomonitoring project, the Caribou project, the Fish and Aquatics project, and the Natural Disturbance project. These initiatives will provide a better understanding about the impact land users have on our forest and our communities. By furthering our understanding about these Sustainable Forest Management issues, land

managers will be better equipped to make decisions that will ensure our forests and communities are healthy today and into the future.

Cumulative Effects

Cumulative effects can be defined as the collective impacts of individual projects on a shared landscape. A wide variety of human activities, including industrial forestry, fire suppression and management, oil and gas exploration and development, mining, recreation and tourism are placing increased demands on the regional ecosystem encompassing FMF. Therefore, our partners have a vested interest in understanding and assessing regional cumulative effects. This project will link to other FMF research areas in order to gain a more complete understanding about the impact that human activities have on the ecological, economic and social health of this region. The anticipated end result of this project will be to provide our partners with accurate information so they can set landscape level objectives for the management of human activities.

Local Level Indicators of Sustainable Forest Management

In 1995, the Canadian Council of Forest Ministers (CCFM) developed a Canadian approach to Criteria and Indicators for Sustainable Forest Management. An indicator is a measurable variable used to report progress toward the achievement of a goal. Foothills Model Forest, along with other members of the Model Forest network, is required to develop a localized set of indicators, compatible with the CCFM criteria, which will work for the landbase contained within FMF. Once local level indicators are developed they are intended to be used by landbase partners in their management plans to measure their performance in implementing SFM ôon the ground.

It is essential that local indicators are relevant to the resources and responsibilities assigned to FMF land managers. Because of this, representatives from Alberta Environmental Protection, the Canadian Forest Service, Jasper National Park, and Weldwood collectively participated in a goal setting exercise. Each organization provided their existing goals and suggestions for new goals. The landbase partners discussed the preliminary goal list and developed new composite goal statements that were acceptable to all. This set of commonly held goals formed the basis for development of local indicators. The FMF partnership was asked to provide lists of existing and suggested indicators, and a workshop was held to organize the list. In 1998/99 priority indicators will be defined. For example, indicators will be developed for forest management, wildlife, and socio-economics.

The goal setting exercise led to a greater understanding about the values, mandate, policies and practices of each landbase partner. Our landbase partners are diverse but their ultimate goals are very similar.

Grizzly Bear

The grizzly bear research project, in conjunction with the Yellowhead Ecosystem Carnivore Working Group (YECWG), is working to gain a better understanding about grizzly bear populations in the Yellowhead region. The Yellowhead region is located in west central Alberta and east central British Columbia, and spans over an area of approximately 60,000 square kilometres. This region has a host of land users whose activities impact upon the environment. This impact may be threatening the health and integrity of the ecosystem on which grizzly bears depend, or may be impacting the bearsÆ ability to effectively use otherwise suitable habitat. This project must also produce a model that provides land managers with an increased understanding about the implications of current and future land use activities on grizzly bear habitat and grizzly bear populations.

In 1997/98 a Request for Proposals was circulated within the academic community to address the issues outlined above. Four recognized grizzly bear experts formed a consortium and submitted a bear research plan for managers in the Yellowhead Ecosystem. Jasper National Park and the Provincial Government have also drafted a Working Framework document to address grizzly bear conservation in the Yellowhead region. The research plan and the Working Framework will provide the Yellowhead Ecosystem Carnivore Working Group with guidance for project implementation.

The Grizzly Bear project is linked to the Cumulative Effects project and the Local Level Indicators of Sustainable Forest Management project.

Why the Grizzly Bear? Grizzly bears are considered by many biologists to be an umbrella species. An umbrella species has large area requirements and general habitat use. By maintaining habitat and area requirements of an umbrella species the ecological requirements of many other species, but not all, may also be conserved. The grizzly bear may also act as an indicator of the integrity and health of other ecosystem processes and wildlife populations.

The grizzly bear is classified as a species at risk in both Alberta and British Columbia. The grizzly bear is susceptible to human disturbance so the increase in recreational use and natural resource extraction activities within the Yellowhead region have significant potential to negatively affect grizzly bear populations. For example, harvest and reforestation creates excellent habitat for grizzlies, but their ability to use it may be adversely impacted by uncontrolled human activity in the same area. For example, some of the more popular recreation sites within FMF are located within such landscapes. The cumulative effects of human pressures and the specific impacts of human activities on grizzly bear mortality and movement were selected as focal points for future management and conservation efforts within the Yellowhead region.

Alberta Forest Biodiversity Monitoring

The Foothills Model Forest has taken a lead role in developing a comprehensive project for monitoring forest biodiversity in Alberta. By coordinating our efforts with others in the province with similar monitoring requirements, an efficient and cost-effective research activity will be possible. Partners include the Alberta Conservation Association, Alberta Environmental Protection, Alberta Research Council, Canadian Forest Service, Parks Canada, and several Alberta forestry companies. When completed, an integrated suite of scientifically sound monitoring procedures will be available for use by the forestry sector, national parks, and possibly the oil and gas sector.

The monitoring of biodiversity is a critical step in the adaptive management process on lands inside and outside the Foothills Model Forest landbase because it defines and reports on indicators of progress in achieving good biodiversity management. In Forest Management Areas and other provincial lands, such an initiative would support the principles of the Alberta Forest Conservation Strategy, which have been endorsed by the Government of Alberta in its Alberta Forest Legacy document. In Jasper National Park and other National Parks, monitoring is key to ensuring that Parks Canada is maintaining ecological integrity. The project is also linked to the Canadian Council of Forest MinistersÆ Criteria and Indicators of Sustainable Forest Management, the Criteria and Indicators of the Montreal Process, and Foothills Model ForestÆs Local Level Indicators of Sustainable Forest Management project.

Project development was the focus of the Alberta Forest Biodiversity Monitoring Project in 1997/98. This involved the following activities:

Informal meetings among government and industry personnel to discuss the benefits of a coordinated approach to monitoring biodiversity.

Preparation of a draft monitoring framework intended to serve as a ôtest bedõ to focus discussion.

Preparation of a review of legislation, policies, external agreements and programs relating to forest biodiversity monitoring in Alberta.

Workshop to discuss goals, principles and approaches.

Formalization of a steering committee to guide project development through December 1999.

Caribou

The Foothills Model Forest Caribou project began in 1993 and concentrated efforts on the Redrock/Prairie mountain caribou herd. Data on caribou distribution, habitat use and population status from a disturbed (harvested) and undisturbed winter range has been collected and analysed. During 1997/98, FMF

initiated a study on the effects of clearcutting on the distribution of the A La Peche herd and development of a forest inventory that would predict the presence of caribou based on a variety of landscape and habitat criteria. An increased understanding about caribou habitat will allow our landbase partners to plan their activities so that caribou habitat can be maintained.

A Better Understanding about The A La Peche Herd à

The winter range of this herd is mainly north of the Berland River.
Typically this herd spends its summers in Jasper National and Willmore Wilderness Park. In the winter the herd migrates into industrial forests, including the forest management areas of Weldwood, Weyerhaeuser Canada Limited, Alberta Newsprint Company, and Canadian Forest Products. WeldwoodÆs Forest Management Area contains about 10% of the herdÆs winter range.

In 1997, twenty-one animals were radio collared, one bull and twenty cows.

The population of this herd was estimated to be about 200 caribou.

In the mild winter of 1998, the A La Peche herd did not migrate into the foothills forests.

In the spring of 1998, thirteen calves were born to the 20 radio-collared cows.

Fish and Aquatics

The Fish and Aquatics project has developed products that are being used in a practical manner by both industry and government. This project continues to provide a foundation for future research that will address Sustainable Forest Management issues. In 1997/98, activities of the Fish and Aquatics project include; the fish and stream inventory, the study of hanging culverts as barriers to upstream fish migration and the production of a visual guide to help improve how fish habitat information is collected. The Fish and Aquatics project is moving towards more directed research which will provide for a broader understanding of fish populations. Extensive information about species distribution and their habitats was required before more focused research could be conducted. The completed inventory will also provide a foundation for long-term monitoring as it relates to both natural and unnatural disturbances.

Fish and Stream Inventory: In preparation for its upcoming forest management plan as well as operating plans Weldwood identified a need for better information on fisheries on its Forest Management Area. Weldwood asked FMF to undertake a new activity, at the companyÆs expense, and since its inception partnerships have been formed with the Alberta Conservation Association and Hinton Fish and Game. The fish and stream inventory activity began August 1995 and by year end 1997, 481 sites were inventoried within the Foothills Model Forest. This activity collects extensive information about fish and their habitats. As the preliminary fish and stream inventory is nearing completion, the 1998 season's field work is focussed on larger water systems.

Culvert Assessment: The Foothills Model Forest and Weldwood recognized the importance of understanding how culverts may accommodate or act as barriers to fish migrations and correcting any problems. The Fish and Aquatics project studied specific crossings to determine what constitutes a barrier to fish passage. Our study indicates that certain culverts were barriers to most of the resident fish. Important ramifications are restricted fish passage and changes to populations through habitat fragmentation. These research findings are significant for future conservation of fish populations in the Foothills Model Forest, and are now being used by Weldwood in its culvert remediation project. They are also of high value for any resource industry or government agency developing roads on the Eastern Slopes of Alberta.

Habitat Manual: A manual consisting of photographs and descriptions of fish habitat for Eastern Slope streams was developed through a joint partnership between the Alberta Conservation Association and the Foothills Model Forest. This visual guide will aid fish and stream inventories by ensuring both consistent and precise data collection and allow organizations to confidently share and exchange information. The habitat manual was tested by Northern Alberta Institute of Technology (NAIT) forestry students and it has proved to be

successful in improving the consistency and precision of data collected. The Alberta Conservation Association has requested the habitat manual for its use in offices in Edson, Rocky Mountain House, and Peace River.

Natural Disturbance

Natural disturbance, primarily wildfire, is a frequent and natural agent of change and renewal in the forests of the mountains and foothills of west-central Alberta. Foothills Model Forest's Natural Disturbance project analyzes and interprets how disturbances (fire, wind, disease) affected the landscape and the forests. By clearly understanding natural disturbance in Foothills Model Forest recommendations can be made to our landbase partners on how to more closely mimic natural disturbance processes, whether it be used in harvest design, prescribed burns or other fuel management strategies.

The Natural Disturbance project is comprised of individual activities that study specific disturbance patterns at various geographic locations and at different scales. The combination of results from the individual activities will provide land managers with a very clear understanding about disturbance trends throughout the entire FMF. In 1997/98, the Natural Disturbance project focused on the Landscape Disturbance Regime, the Detailed Disturbance History of the Montane Ecoregion, and the Island Remnants activities.

Landscape Disturbance Regimes: The Landscape Disturbance Regime project is the foundation of the Natural Disturbance project. This activity describes natural disturbance, including data about the frequency, type and rate of disturbance, across approximately 2.75 million hectares of Foothills Model Forest, including Jasper National Park, WeldwoodÆs Forest Management Area and provincial lands east of the front range of the Rockies. In 1997/98 a stand origin map of FMF, excluding Willmore Wilderness Park was completed. The stand origin map can be used to determine historical disturbance, frequency and size of stand-replacing wildfires.

Detailed Disturbance History of the Montane Ecoregion: The Montane Ecoregion in Jasper National Park and the Upper Foothills Subregion were shaped by a variety of natural disturbances such as surface fires, disease and windfall. Because of their complex natural disturbance history, these areas cannot be represented by stand origin mapping alone. A detailed disturbance history of these areas will provide Jasper National Park with a better understanding about the frequency and nature of fires, fire effects on tree population, understory, plants and animals. 1997/98 was the first year of this project and focused on research methodology and data collection.

Island Remnants: The pattern of trees that remain after individual wildfires are called island remnants. This research is focussed on the size, number and arrangement of island remnants in relationship to attributes such as fire size and topographic features (eg. streams). Island Remnants offer a potentially useful template for land managers attempting to maintain patterns of forest age classes within the range of natural variability. In 1997/98 a draft report was complete that described methodology and preliminary results. Historical photos were also located and interpreted with information from the photos captured in the GIS system for future research.

McGregor Model Forest

Bruce MacArthur

Introduction

The Province of British Columbia is extremely diverse ecologically, but this has only been meaningfully appreciated in the last several decades. There is now recognition that the diversity and variability of the province's ecology is, indeed, its strength, which if managed intelligently will ensure sustainable forest management and the many benefits of community well being. While diversity and variability represent strength, they also represent a challenge to those whom are faced with the need to monitor it over time and interpret this information to develop adaptive strategies to ensure sustainable forest management.

With the implementation of its program in Phase I, the McGregor Model Forest has focused on the development of decision support technologies of sustainable forest management which is, among, other things, capable of forecasting indicators. However, before proceeding to this stage it was necessary to identify indicators that could be supported by the retrospective studies of the Ecological Processes and Forest Practices Program Areas. As each of these programs neared completion a workshop was held to identity indicators at which time 33 indicators were listed under the Criteria: Conservation of Biological Diversity, Maintenance and Enhancement of Forest Ecosystem Condition and Productivity, and Conservation of Soil and Water Resources.

With reference to the development of indicators of biodiversity, no projects were specifically designed to develop indicators of biodiversity. Instead, it was through the variety of projects undertaken that relationships were considered, understanding was developed, and conclusions were drawn that seemed to reflect our beliefs about what biodiversity is and how it might be represented by indicators.

In support of the program work of the Ecological Processes and Forest Practices Teams, additional work has been undertaken to complete an intensive resource inventories of the McGregor Model Forest and to conduct bird surveys. The advantages offered by these projects lie in being able to identify the variety of resource values throughout the model forest and to develop base line information on bird species and their distribution across habitat types. Changing financial conditions however, required modifcations to each project, but nevertheless, valuable information will be acquired once both projects have been completed and will used to supplement existing lists of indicators of biodiversity.

Indicators of Biodiversity

To date, the indicators of biodiversity that have been identifed as being plausible for use on the McGregor Model Forest are listed in Table 1

Table 1. Summary of indicators of biodiversity by critical element of Criterion 1 identified by the :McGregor Model Forest.

Criterion 1

Conservation of Biological Diversity:

the variability among living organisms from all sources and the ecological complexes of which they are part.

(Maintenance of natural genetic and ecosystem diversity across the landscape is the key to ensuring that species maintain viability through their capacity to evolve and to adapt to change.

Critical Elements
Ecosystem diversity
Species diversity
Genetic diversity

Critical Element	MMF Indicators	Other Indicators
1.1 Ecosystem diversity Ecosystem diversity is the variety and pattern of communities and forest type ecosystems. Maintenance of this variety is critical for the maintenance of presentation of species	1.1.1 Gap size: shape and distribution 1.1.2 Tree species composition by 1.1.3 Percentage of landbase / spatial distribution of structural classes (vertical and horizontal) non-forested habitat 1.1.4 Extent and number of island remnants by patch size 1.1.5 Percentage of shape index in different opening size classes 1.1.6 Amount of unsalvaged burned forest < 40 years since disturbance vs. historic levels	> Degree of fragmentation and connectiveness > Patch size and distribution > Adherence to the BC FPC Biodiversity Guidelines

Table 1. (Con't) Summary of indicators of biodiversity by critical element of Criterion 1 identified by the :McGregor Model Forest.

Critical Element	MMF Indicators	Other Indicators
1.2 Species diversity The greatest and most recognizable form of bio-depletion lies with species extinction. Slowing down the rate of species extinction is a key objective of the conservation of biodiversity.	1.2.1 Red/blue listed species (blue listed species done for Prince George District) 1.22 MMF to focus on sensitive species 12.3 Size and number of island remnants of undisturbed forest in harvested areas	> Management of unique populations and degree of change > Change in critical food source e.g. arboreal lichens
1.3 Genetic diversity Genetic diversity or the variation of genes within a species is the ultimate source of diversity at all levels. Loss of variation may have negative consequences for fitness and prevent adaptive change in populations.	1.3.1 Conservation of genetic variability in important tree species in the McGregor Model Forest .e.g. weevil resistant seed sources 1.3.2 Area, percentage and representativeness of forest types in protected areas 1.3.3 Areas of old growth at the extreme of the distribution in important tree species in the MMF 1.3.4 Amount of ex-situ conservation (seeds, tissue culture, pollen)	

The above indicators remain to be scrutinized for their representation of biodiversity, in other words, if it were to be monitored, would the information provide a window to the maintenance of biodiversity at the landscape level? The McGregor Model Forest recognizes that it is not possible under the present level of resource availability to fully evaluate all possible indicators of biodiversity. Instead, efforts are now being directed at evaluating its current list if indicators against the broad objectives of the Prince George management principles. Maintenance of biodiversity is a high priority for the province and as such, allows for the McGregor Model Forest to work collaboratively with the province irt developing, testing and validating indicators of biodiversity within an adaptive management framework. Teaming with agencies and partners with expertise in areas of genetics is likely should it be deemed necessary, but this may only happen through a provincial initiative. The McGregor model Forest does not have the expertise to undertaken genetic monitoring of biodiversity and it is unlikely that indicators of this critical element would be monitored routinely.

Monitoring

The McGregor Model Forest is moving quickly forward with the development of a beta version of a monitoring program of practical indicators across each of the six CCFM Criteria. This has begun by consolidating lists of indicators that through a screening process are reduced to a practical number that are further evaluated against operational objectives and probabilities of successful implementation. -

Where to now?

The McGregor Model Forest is capitalizing on its principle partner's need to develop a Management Plan to initiate a scenario planning exercise that will necessitate the implementation of every aspect of its past work, understanding, and decision support technologies. Apart from other elements of the exercise it will also require that indicators be selected and monitoring plans be developed for each indicator.

At this time there is certain excitement in what the McGregor Model Forest is doing because it all comes down to the question: /s sustainable forest management achievable? We definitely believe that it is, but only with a good planning approach within an adaptive management framework, the development of sensitive implementation strategies, the monitoring of appropriate indicators and a willingness to make changes if necessary.

Current Work on Selection and Application of Indicators of Biological Diversity at the Long Beach Model Forest

Barb Beasley, Research Coordinator, Long Beach Model Forest Society

The Long Beach Model Forest has formed a working group to oversee the development and application of local level indicators for conserving biological diversity and in relation to the other criteria of the Canadian Council of Forest Ministers. The group consists of representatives from the Pacific Rim National Park, B.C. Ministry of Forests, B.C. Ministry of Environment, Lands and Parks, the Clayoquot Sound Planning Committee, the Ma-Mook Development Corporation, and Macoah Excavation, a local First Nation's forest company. Our approach is to consult with our partners, the Model Forest Network, and outside agencies that have been involved in monitoring to develop a comprehensive monitoring framework for the Long Beach Model Forest area.

We recently participated in the Pacific Rim National Park Workshop on Assessing Ecological Status. This workshop involved experts from agencies in the region (e.g., Dept. of Fisheries and Oceans, Bamfield Marine Station, Strawberry Island Research, B.C. Ministry of Environment) who were willing to share information about their current monitoring and research initiatives and to work towards identifying specific indicators, protocols/protocol development, potential partnership arrangements and operational issues for monitoring the ecological integrity of the Park and surrounding area. We will refine and adapt what was developed with the Pacific Rim National Park and partners after consideration of input gathered at this Biodiversity Workshop and at a Criteria and Indicators Workshop to be hosted by the Long Beach Model Forest

on November 12-13. We have set a goal to have a framework for operationalizing the monitoring recommendations of the Clayoquot Sound Scientific Panel by February 1999.

The scope of this work is somewhat daunting but we are not starting from scratch. LBMF has been working on inventories and research projects that relate to monitoring biological diversity since 1996. The following outlines four major studies:

Riparian Management Project - The Ecological Requirements for Riparian Buffers Around Continuously-Flowing, Seasonal and Ephemeral Headwater Streams in Clayoquot and Barkley Sounds

The Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (1995) calls for greater riparian protection around small headwater channels than does the B.C. Forest Practices Code (1995). The discrepancy results from a lack of information about the hydroriparian communities of small headwater streams (seasonal flow, class S5/6, <1.5m wide, without fish habitat) and the ecological impacts of harvesting around them. Our study objective is to monitor the communities of aquatic benthic invertebrates, vascular plants and amphibians within the hydroriparian ecosystem pre- and post-implementation of riparian management in Clayoquot Sound (Scientific Panel standards) and Barkley Sound (Forest Practices Code).

We monitored streams in old growth and 4-8 year old clearcut sites in three watersheds for two years. From this work, we gained some idea of the biodiversity and community structure of benthic invertebrates and vascular plants. We identified several key taxa and measures of community structure that may serve as indicators of the effectiveness of different riparian management zones. For example, the relative abundance of the invertebrate family, Ameletidae, was higher in harvested areas than old growth, the ratio of the number of shredder to scraper families was higher in old growth than harvested areas, the stream violet and sitka sedge were found up to 60m from the edge of the water in old growth and only up to 10m from the edge of water in harvested sites, and the one exotic species of plant, wall lettuce, was found only at harvested sites. This baseline work was important in helping us identify specific indicators of change in the composition of local riparian communities.

Clayoquot Sound Amphibian Inventory

Given the world-wide decline in amphibians, their dependence on moist terrestrial habitats, as well as wetlands, and their prevalence in coastal rainforests, they are an important taxonomic group to consider for monitoring biodiversity within the Long Beach Model Forest area. For the past two years, LBMF has inventoried wetlands within different watersheds of Clayoquot Sound to locate and characterize breeding sites of aquatic breeding species (the Northwestern Salamander, Roughskin Newt, Pacific Treefrog, Redlegged Frog and Western Toad). Our aim has been to gain information about habitat features that are associated with a high diversity and abundance of amphibians and the occurrence of rare species (e.g., the Western Toad) so that we can tell land planners what habitats and habitat elements/structures to protect. It will be critical to monitor whether the protection that is offered is sufficient to preserve healthy breeding populations.

The other component of the amphibian inventory involves surveying terrestrial amphibians in the forested riparian areas of headwater and valley bottom streams and wetlands. In 1997, we found more western redback salamanders closer to the water's edge than farther away in developed watersheds and an even distribution across riparian zones in undeveloped watersheds. This work is being repeated in 1998 to determine whether watershed development has an effect on distribution patterns across a broader range of sites. It will be interesting to determine whether different widths of buffering around headwater streams further influence the distribution of Western Redback Salamanders.

The Effects of Stand Age and Composition on Epiphytic Lichens in Clayoquot and Barkley Sounds

Recognizing that forest management modifies stand age and structure, as well as the surrounding landscape, in ways that alter opportunities for lichen growth and dispersal, we investigated how epiphytic lichen abundance and composition (proportion of alectorioid and cyanolichens) change with stand age, type and location.

We found that epiphytic lichen abundance increased with stand age. Although young mature stands (70 - 120 years) were small and contained structural remnants of old growth, they had less lichen than old mature (160-200 years) and old growth stands (300 + years). It appeared that remnant structures left in mature stands did not fully compensate for forest age. This finding indicates that lichens could be a good indicator of how well reserves of variable size conserve biodiversity within landscapes.

Collecting lichens from litter and sorting them into functional groups was a quick and easy way to detect differences between old growth and young-mature forests but we missed rare old-growth dependent species. It will be important when monitoring biodiversity to conduct a more detailed examination of focal species, such as the two that are listed as critically imperilled in B.C. and are known to occur in the area, *Erioderma sorediatum* and *Heterodermia sitchensis*. The lichen study, like the others, produced baseline information, tested protocols, and provided cost estimates which will be invaluable in helping to select indicators for monitoring.

First Nations Perspectives on Wildlife Inventories in Clayoquot Sound

This ongoing study involves a collaboration between Ruth Ogilvie of the Tla-o-qui-aht First Nation, participants from the five Central Region Nuu-Chah-Nulth First Nations and the LBMFS research department. Our aim is to document First Nations' perspectives, attitudes and traditional knowledge related to wildlife and conservation in Clayoquot Sound. We are doing this by interviewing people with traditional knowledge from the five First Nations in Clayoquot Sound. The approach and results to-date will be presented in a separate talk at the workshop.

Session Two - Guest Speakers

A 30 minute plenary discussion occurred with the invited speakers for questions, discussions and identification of opportunities for cooperation or identification of potential new Strategic Initiatives and projects that can be considered by the Local Level Indicators Working Group in the development of future workplans

Monitoring ecosystem diversity for sustainable forest management.

Daniel R. Farr

Abstract

The diversity of local ecosystems within a landscape profoundly influences the ecological and cultural values available at any given time. By suggesting potentially useful measures of ecosystem diversity, the Canadian Council of Forest Ministers (CCFM) has highlighted the importance of an ecosystem perspective in sustainable forest management. In this paper, considerations for monitoring ecosystem diversity in CanadaÆs boreal forest are reviewed, including discussion of boundary identification, data sources, ecosystem diversity measures, and reporting. Of the three major causes of ecosystem boundaries (landform, disturbance, roads and other linear developments), the dynamic nature of disturbance and linear developments make them important elements to monitor. Aerial photographs and satellite imagery are valuable sources of data, although accurate and consistent delineation of boundary features may be difficult depending on disturbance history and land use history. Of the many spatial and non-spatial measures of ecosystem diversity, the CCFM has proposed four non-spatial ones, applying a very broad definition of ecosystems: 1) Percentage and extent, in area, of forest types relative to historical condition and to total forest area; 2) Percentage and extent of area by forest type and age class; 3) Area, percentage and representativeness of forest types in protected areas; and 4) Level of fragmentation and connectedness of forest ecosystem components. Of the many spatial metrics available, it is possible with appropriate data to report a relatively small number of simple ones that would inform management. Improved coordination and collaboration among agencies attempting to monitor ecosystem diversity would advance progress towards sustainable forest management, and the Model Forest Program offers a significant opportunity to do so.

Key Words

disturbance, ecosystem diversity, landscape pattern, land use, linear development, monitoring, patch, roads, sustainable forest management

I Introduction

The Canadian Council of Forest Ministers (1995) defined biodiversity as the variability among living organisms and the ecological complexes (ecosystems) of which they are a part, and divided biodiversity into three broad elements: ecosystem diversity, species diversity, and genetic diversity. While the utility of the biodiversity concept is problematic given its all-inclusive nature (Lautenschlager 1997), it can focus attention on ecological variability across a hierarchy of scales and levels of organization (Noss 1990), and biodiversity conservation has become a cornerstone of sustainable forest management in Canada (Canadian Council of Forest Ministers 1992). Conserving biodiversity at all scales is considered prudent given the uncertainty of future social and economic uses of biodiversity, and with respect to forestsÆ ability to persist under changing climate and other global conditions (Minister of Supply and Services Canada 1995, Canadian Forest Service 1997).

Of the three elements of biodiversity identified by the Canadian Council of Forest Ministers (1995), ecosystem diversity is probably the least difficult to measure and monitor. Compared to the number of species (70,000 identified in Canada, Brouard and John 1997) and genes (thousands per species), the number of

ecosystems to be identified, counted and measured is relatively small. However, because ecosystems are not discrete biological entities like species and genes (Hunter et al. 1988), defining what constitutes an ecosystem is problematic. The absence a of consistent definition has constrained progress towards effective monitoring. Another difficulty is the lack of a comprehensive understanding of the relationship between ecosystem diversity and other elements of biodiversity such as species and genes. Even simple measures, such as area by ecosystem type, are difficult to interpret because of incomplete knowledge of species habitat requirements. Nonetheless, there is growing recognition that ecosystem diversity is a fundamental property of ecological systems (Baker 1989, Turner 1989), and should be monitored as such. Monitoring ecosystem diversity is part of an adaptive management strategy in which the maintenance of major ecosystem types is considered a coarse-filter approach (Duinker 1993, Hunter et al. 1988) to conserving biological diversity. Unlike species diversity and genetic diversity, it is also possible to estimate the historical range of variability for some measures of ecosystem diversity, which can assist in setting targets for land management (Swanson et al. 1993).

Because human activities such as forest harvesting and road construction directly influence ecosystem diversity (Punkari 1984, Cohen et al. 1996, Reed et al. 1996), and indirectly influences species diversity and genetic diversity, monitoring ecosystem diversity is one way to track the magnitude of human influence. In general, human activities tend to simplify landscapes (Turner and Ruscher 1988), although individual parameters of ecosystem diversity may increase or decrease depending on the spatial scale being considered (Mladenoff et al. 1993). In addition, changes in the composition and structure of ecosystems within landscapes affect the availability of economic, social and other values, and also affect other aspects of biological diversity at species and genetic levels. For example, the creation of an increasingly complex mosaic of patches because of disturbances, including human activity (ôfragmentationõ, Li et al. 1993) is thought to affect the metapopulation dynamics of certain species (Wilcove et al. 1986, Saunders et al. 1991). The mechanism frequently invoked, and for which there is considerable evidence, involves interspecific interactions such as predation and parasitism which may increase along the edges between different ecosystems (McGarigal and McComb 1995). For example, nest predation rates for some songbird species may be greater near edges than further away (Gates and Gysel 1978, Wilcove 1985).

Although ecosystem-level targets for land management will continue to move in response to changing societal expectations, there is a consistent trend towards increasingly sophisticated reporting of trends at all levels of biological diversity, including ecosystem diversity (Hansen 1995, Committee on Environment and Natural Resources 1997). Effective monitoring of trends in ecosystem diversity requires a meaningful and consistent definition of ecosystems, access to appropriate data and analytical tools, and suitable mechanisms for reporting. The purpose of this paper is to review a series of considerations relevant to monitoring ecosystem diversity in CanadaÆs boreal forest, including discussion of boundary identification, data sources, ecosystem diversity measures, and reporting.

2 Elements of ecosystem diversity

2.1 What is an ecosystem?

2.1.1 General considerations

A consistent and meaningful definition of ecosystems is a prerequisite for effective monitoring. While there is no single ôcorrect definition, a focus on the processes that cause relatively rapid change in ecosystem composition, structure and function is appropriate in the context of monitoring change through time. Monitoring changes associated with natural and human-caused disturbance, along with linear developments, all in relation to enduring landforms, contributes to an informed assessment of trends in biodiversity.

In general, an ecosystem is ôa relatively homogeneous area of organisms interacting with their environment Forman (1995:38), which may occur in one of three forms: patches, corridors, or area of matrix (Forman 1995). In this definition, an ecosystem is an area (or volume) based entity (which can therefore be mapped), containing an assemblage of interacting species that form a community. Forman and Godron (1986)

also identified five distinct types of vegetation patches (ecosystems) based on their cause or origin: i) disturbance patches (caused by disturbance); ii) remnant patches (that escape disturbance); iii) environmental patches (caused by patchiness in the environment); iv) regenerated patches (regrown after disturbance); and v) introduced patches (created by people).

In a hierarchical framework, ecosystems are contained within landscapes, with a landscape defined as a mosaic where a cluster of local ecosystems is repeated in similar form over a kilometers-wide area (Forman 1995:39), or a complex of systems, formed by the activity of rock, air water, plants, animals, and man, that by its physiognomy forms a recognizable entity (Zonneveld 1979 in Eng 1998:43). Although the size of ecosystems and landscapes depends on the criteria used to delineate them, a 1:20,000 aerial photograph taken over the boreal forest typically contains more than one ecosystem but only a small part of a landscape. The satellite image in Fig. 1 could be described as containing many ecosystems (e.g., recent burn, clearcuts) in a portion of the Liard River valley (a landscape) in southwestern Yukon.

The processes that generate ecosystem boundaries are fundamentally important to the biological integrity of a region (Baker 1992) because they affect the composition, structure and function of ecosystems (Franklin 1993, Noss 1990). Three types of ecosystem boundaries are recognized in this paper, defined by the process that causes them: landform, disturbance, and linear developments.

Historically, ecosystem boundaries have been generated by processes acting over very long time scales such as glaciation and other landform-building processes, and those acting over much shorter time scales such as disturbance (Brouard and John 1997). In the boreal forest and many other regions, the boundaries generated by these two groups of processes overlap (Pickett and White 1985), and it is helpful to distinguish each when delineating ecosystems. In addition, natural disturbance regimes may vary among landforms or landform categories, generating a range of variability in ecosystem diversity that is an inherent characteristic of a particular landform or landform category (e.g., Andison 1996, Francis 1996, Swanson et al. 1988). For example, disturbance patches generated by wildfire in the Upper Foothills portion of the Foothills Model Forest are larger and more variable in size than those in the Lower Foothills (Andison 1997, Fig. 2). Such information is useful for partitioning the spatial variability in disturbance regimes, so that the effects of human activity are viewed in the context of natural variability.

In recent times, many ecosystem boundaries have also been caused by the construction of roads and other linear developments. These boundaries both dissect ecosystems (Reed et al. 1996) and influence their internal structure, composition and function (Niemi and Hanowski 1984). Monitoring temporal trends in the extent and distribution of these ôintroduced features (Forman and Godron 1986), along with those generated by natural and human-caused disturbance, provides additional feedback for adaptive management.

2.1.2 Landform patches

Forman and Godron (1986) referred to patches caused by inherent variability in the environment as (environment patches). While such patches are observable at a range of spatial scales, the boundaries associated with ôlandform are probably the most appropriate to consider when monitoring ecosystem diversity (Brouard and John 1997). Landform is the result of surface relief / topography and surficial parent material (Rowe in press), which generates spatial and temporal variability in physical environmental conditions (Fig. 3). Landform causes both gradients and abrupt changes in temperature, moisture, insolation and other edaphic factors that vary across a landscape. The definition of landform is scale-dependent: a large region of hilly terrain and a southeast-facing slope within that region are the product of landform processes operating at different spatial scales.

While the ecosystem boundaries associated with landform are relatively ôstatic within the timeframe of a monitoring program, they provide an ecologically meaningful context (Hansen 1995) for stratifying and interpreting the more rapid ecosystem boundary changes associated with disturbance and linear developments.

2.1.3 Disturbance patches

As noted above, disturbances cause relatively rapid change within boreal forest landscapes, and thus the modification of natural disturbance processes affects ecosystem diversity (Swanson et al. 1988). In managed landscapes, natural disturbances are often suppressed, inhibited or modified, and new disturbance types such as clear-cutting are introduced (Fig. 4). Monitoring the composition, dimension, and spatial arrangements of patches generated by both natural and human-caused disturbance processes is therefore a primary consideration in forest management.

Picket and White (1985:7) defined disturbance as ôa relatively discrete event in time that disrupts ecosystem, community or population structure and changes resources, substrate availability, or the physical environment. Wildfire, windthrow, flooding, insects and disease are all major forms of natural disturbance in boreal forest systems (Picket and White 1985), and forest harvesting is frequently viewed as another, albeit recently introduced, disturbance type (Franklin and Forman 1987, Hunter 1993). Each disturbance event generates a patch ("disturbance patch" Forman and Godron 1986) with many disturbance-related attributes, including type, size, shape, intensity, severity, timing, spatial location, edge, and orientation (Baker 1992). The distribution of values for each of these attributes constitutes the disturbance regime of a landscape, which is an important source of both spatial and temporal ecological variability (Baker 1992). Temporal variability in disturbance is far from constant over time, and over much of the boreal forest, ecosystem diversity changes abruptly during episodic fire years or insect outbreaks, with little change during intervening years with relatively low incidence of disturbance (Johnson 1992).

2.1.4 Roads and other linear developments

Forman and Godron (1986) referred to patches created by people as ôintroduced patches. While many such patches in the boreal forest are non-linear (e.g., industrial facilities, mines, well sites, urban developments), the following discussion includes only linear developments (perhaps more accurately considered ôcorridors, Forman 1995), which are an important source of ecosystem diversity in forested regions (Canadian Council of Forest Ministers 1996). Linear developments may be defined as man-made features constructed for the purpose of transporting people, materials, energy, or all three. In addition to the many grades of roads and trails, linear developments include power lines, railways, pipelines, and petroleum exploration (e.g., seismic) lines.

Five ecological functions attributed to corridors in general also apply to roads and other linear developments: these include habitat, conduits, filters, sources, and sinks (Forman 1995). In forests, considerable evidence suggest that roads affect the structure, composition and function of ecosystems and populations (e.g., Oxley et al. 1974, Armor and Stevens 1976, Niemi and Hanowski 1984, Theil 1985, McLellan and Shackleton 1988, Eaglin and Hubert 1993, Mladenoff et al. 1996). For example, roads may be the major features responsible for the fragmentation of ecosystems in the US Rocky Mountains (Reed et al. 1996).

2.2 What is ecosystem diversity?

Ecosystem diversity, as described by the Canadian Council of Forest Ministers (1995), refers to the variation among ecosystems within a landscape, and includes measures that characterize their dimension, composition, and spatial arrangement (Eng 1998). All such measures require that ecosystems be delineated in a consistent fashion, and as discussed above, three types of ecosystem boundaries are particularly relevant to monitoring for sustainable forest management: landform, disturbance, and linear developments (Fig. 5).
Ecosystem diversity as described here is the same as regional landscape diversity (Noss 1983, 1990), landscape diversity (Romme 1982, Suffling et al. 1988), landscape pattern (Franklin and Forman 1987, OÆNeill et al. 1988, Ripple et al. 1991), and landscape structure (Garman and Bradshaw 1993, McGarigal and Marks 1994). While each of these sources relates generally to ecosystem diversity, the criteria used to define ecosystems and the methods used to delineate their boundaries vary widely. In the following section, a sample of ecosystem diversity studies is reviewed.

3 Changes in ecosystem diversity: Previous research

Studies of change in ecosystem diversity may be divided into two groups: comparisons of ecosystem diversity at a single location for different times in the past, and comparisons of ecosystem diversity among locations. The first group, temporal comparisons, may be further subdivided into studies that use historical estimates of disturbance history to generate estimates of disturbance-generatedpatterns for different times in the past (e.g., Romme 1982, Wallin et al. in press), studies that compare two or more ecosystem maps of the same area (e.g., Reed et al. in press, Ripple et al. 1991), and studies of temporal trends in linear developments (e.g., McLellan 1990, Reed et al. 1996, Sawyer 1998).

Romme (1982) described changes in ecosystem diversity in a 7,300 ha landscape in Yellowstone National Park over a 240-year period from 1738 to 1978. Broad ecosystem types representing different successional stages were mapped from aerial photographs, and dated using fire history methods. Fires occurring in six different years during this period caused considerable changes in ecosystem diversity, as measured by three indices related to the richness, evenness, and patchiness of local ecosystems. A habitat supply analysis suggested that these changes in ecosystem diversity likely caused corresponding changes in bird and ungulate populations (Romme and Knight 1982).

A study of landscape pattern in Oregon showed similar changes in ecosystem diversity for two study sites between the late 1400Æs and 1990 (Wallin et al. in press). Data were obtained from fire history studies and reconstruction of harvest history between 1950 and 1990. Three measures of ecosystem diversity were calculated: 1) density of edges between young (<40 years) and mature (>40 years) forest; 2) percent of landscape in mature forest; and 3) percentage of interior mature forest >100 m from the edge of a young forest patch. Edge density in 1990 (generated entirely by logging) was very high (35 m/ha) and beyond the estimated range of variability of that generated by periodic wildfire episodes during pre-settlement times (0-15 m/ha). This increase in edge density during the period of logging was accompanied by a decline in the percentage of interior mature forest (60% in 1990), although this was within the range of historical variability believed to have been generated by wildfires (0 û 90%). The overall percentage of mature forest in 1990 (75%) was also within the range of conditions thought to occur prior to logging (0-100%).

Ripple et al. (1991) compared ecosystem diversity in western Oregon in 1972 and 1987 using 1:15,850 vegetation maps obtained from the US Forest Service. Fifteen landscapes approximately 1750 ha in size were randomly selected, each containing an average of 10 and 20 patches in 1972 and 1987, respectively. A comparison between the two years illustrated the increased fragmentation associated with clearcut logging, as measured by several indices of ecosystem diversity, including mean patch density (98% increase), interpatch distance (29% decrease), and percentage of interior mature forest (18% decrease).

Reed et al. (in press) compared ecosystem diversity in a 35,000 ha area in southeastern Wyoming during the period 1950 û 1993 using mapped vegetation data and harvest records obtained from the US Forest Service. The approximately 30 ecosystem types were defined based on both dominant vegetation and disturbance history, and it was assumed that the vegetation structure and composition of clearcuts remained distinct from the surrounding unharvested forest matrix during the 43-year study period. Several measures of ecosystem diversity were calculated at intervals during the study period (e.g. patch density, patch size, mean patch perimeter, patch shape, Shannon diversity, contrast, dominance), all of which illustrated the landscape changes associated with clearcutting. In addition, the authors concluded that the study landscape had become even more fragmented than higher-profile areas of the Oregon Cascades described by Ripple et al. (1991).

In a study of ecosystem diversity in the Foothills Model Forest of western Alberta, Andison (1997) used a stand origin map showing historical fire boundaries (obtained from 1:40,000 aerial photographs, Rogeau 1996) and historical cutblocks. A comparison of landscape pattern in 1950 (pre-logging) to that in 1995 suggested that patches of young forest (<40 years, fire-origin and harvest-origin) and older forest (>200 years, fire-origin) had become more fragmented, primarily due to harvesting activity (Fig. 6). Measures used to support this conclusion included patch size, interior forest area, edge density, and an estimate of patch heterogeneity (Andison 1997).

In a study of the extent and distribution of linear developments, Mladenoff et al. (1995) estimated road density for an area of approximately 80,000 km2 area of northern Minnesota, Wisconsin and Michigan, using digital data obtained from the U.S. Census Bureau. Road densities across the study area (not including unimproved forest roads and trails) ranged from 0 km/km2 to >1.5 km/km2. The road data, accompanied by vegetation and other information, was used to predict probabilities of wolf occurrence across the study area (Mladenoff 1996).

Sawyer et al. (1998) calculated road densities in a 2,456 km2 area of southwestern Alberta between 1880 and 1996, with approximately 4100 km (1.7 km/km2) of linear disturbances of all types in 1996, including unimproved roads, trails, and seismic lines. The increase in road density during the study period was roughly exponential.

Finally, in a comparison of ecosystem diversity among locations, Mladenoff et al. (1993) described differences between two landscapes in north-central Wisconsin, based on dominant vegetation cover, mapped from 1:24,000 color infared aerial photographs. Ecosystem diversity was described using several metrics, including patch composition, patch size, patch complexity, and adjacency measures. Comparisons between the two landscapes (one 7,200 ha landscape dominated by managed second-growth forest, and one 9,600 ha landscape dominated by natural old-growth forest) revealed that forest patches in the more natural landscape spanned a larger size range (1 to >1000 ha vs. <1 to 200 ha), contained more interior habitat, and were more complex in shape, than patches in the managed landscape. Clear differences in ecosystem diversity between the two landscapes were associated with different land use histories. The results were used to suggest a landscape design that would more successfully maintain both old-growth forest and timber supply than past management practices.

4 Boundaries of ecosystems

4.1 Landform patches

Prior to calculating measures of ecosystem diversity (section 6), it is necessary to generate maps showing the boundaries of individual ecosystem patches. Boundaries associated with landform change very slowly relative to those generated by disturbance and, once delineated, such boundaries may be considered ôpermanent. In some areas, maps on which appropriate landform boundaries are delineated may already exist. In other areas, only very broad landform categories have been delineated, and more detail is required.

Landform is incorporated into ecological land classification systems developed and implemented in many parts of Canada (e.g., Meidinger and Pojar 1991, Strong 1992, Achuff 1994, Fig. 7), although the range of spatial scales (minimum polygon size) varies considerably. The Ecological Stratification Working Group (1995) has developed a framework for integrating different ecological land classification (ELC) systems across Canada. The framework is hierarchical, and includes ecoregions (characterized by distinctive large order landforms or assemblages of regional landforms, small order macro- and mesoclimates, vegetation, soils, water, and regional human impact patterns/uses) and ecodistricts (subdivisions of ecoregions characterized by distinctive assemblages of landform, relief and surficial geologic material, soil, water bodies, vegetation and land uses, Ecological Stratification Working Group 1995). In most areas of the boreal forest, ecodistricts may be too large to be of value in delineating ecosystems, and it would be necessary to apply finer-scaled classification systems (e.g., Meidinger and Pojar 1991, Beckingham et al. 1997) or generate boundaries associated with topography using a digital elevation model (e.g., Andison 1996, 1997). Watersheds (Omernik and Bailey 1997), formed by landform processes, are also a useful way to delineate enduring landform features.

4.2 Disturbance patches

Identification of disturbance patches, particularly those generated from natural processes, is probably the most technically difficult aspect of monitoring ecosystem diversity. In practice, only a small subset of disturbance-generated boundaries are visible using commonly available data sources such as aerial photographs

and satellite imagery. For example, disturbance patches generated by recent, large, intense wildfires are readily visible on most conventional aerial photographs (Lorimer 1985, Rogeau 1996), while those generated by light surface fires or moderate insect outbreaks are more difficult to detect without extensive field sampling (Lorimer 1985, Arno et al. 1993). Also, because disturbances overlap, the boundaries of previous disturbances are obscured by more recent ones. Not surprisingly, most studies of ecosystem diversity have considered only large, stand-replacing fires (e.g., Romme 1982, Andison 1997, Wallin et al. in press), or clearcut openings (Reed et al. in press). Studies of a broad range of disturbance types (e.g., Tande 1979, Arno et al. 1993, Francis 1996) require considerably more effort per unit area, and it may be impractical to apply such intensive methods to monitor ecosystem diversity across large regions. However, recent advances in remote sensing may make it possible to detect boundaries generated by within-stand disturbances such as insect infestations and partial harvesting (Pitt et al. 1997).

Vegetation on either side of a disturbance patch boundary may converge towards a similar composition and structure through time because of vegetation succession. The rate at which the boundary between adjacent patches appears to dissolve would vary according to the attributes used to define patches and the method used to delineate them (e.g., aerial photos vs. satellite images). Thus, the definition of a single ecosystem patch within a landscape may change through time depending on the characteristics of adjacent patches.

The question of whether adjacent patches should be considered one patch can arise only if individual patch boundaries are known. For example, two adjacent patches, with origin dates of 1994 and 1999, may be considered separate patches in 1999, but may be considered a single patch in the year 2030. Unfortunately, in many cases, most patches have unknown dates of origin. In regions with relatively infrequent disturbance, much of the area is considered a single patch within which historical disturbances have probably occurred, but the boundaries of individual patches are unknown (Lorimer 1985). Such regions lack a historical context with which to compare present and future values of measures of ecosystem diversity.

5 Sources of data

5.1 General considerations

As revealed in the previous sample of ecosystem diversity studies (section 3), a range of data sources may be used to delineate ecosystems. Within the context of monitoring, an emphasis on relatively dynamic features, namely disturbance patches and linear developments, is recommended. It is important that the method used to delineate such features is repeatable, so that maps illustrating equivalent ecosystems are available for comparison. Finally, because estimates of historical variability in ecosystem diversity provide a useful context for present and future land management, data sources showing past conditions (e.g., historical maps aerial photographs) may also be useful, depending on the criteria applied when delineating ecosystems.

Because natural disturbance patches vary greatly in size, it is important to consider the spatial scale at which they are delineated. Depending on the disturbance type, patch size may span up to several orders of magnitude (Urban et al. 1987). For example, wildfires in the boreal forest range from less than one hectare to over 100,000 hectares in size (Johnson 1992). In addition, a single large wildfire generates many individual disturbance patches, and the ability to distinguish each patch depends on data resolution, such as the scale of an aerial photograph. While there is no ôright scale, consistency is important if the data are used to track changes through time (Skovlin and Thomas 1995, Hart and Laycock 1996).

5.2 Aerial photographs

5.2.1 Vegetation cover maps

Maps showing the boundaries of individual vegetation patches (e.g., forest stands) are a potentially valuable source of data for measuring ecosystem diversity, and have been used in many studies (e.g., Ripple et al. 1991, Mladenoff et al. 1993, 1994, Cumming et al. 1995b, Reed et al. in press). On most such maps, stands are interpreted from aerial photographs, with variability in tone and texture used to delineate stands based on

vegetation structure and species composition (Pitt et al. 1997). Roads and other linear developments are also frequently recorded on such maps, as are patches generated from recent disturbance events such as forest fires and harvesting activity (e.g., Government of Alberta 1991).

Because features other than disturbance patches are also used to mark boundaries on vegetation cover maps (e.g., Alberta Vegetation Inventory, Government of Alberta 1991) it may be difficult to determine the cause of patches on such maps. Thus, patches generated by disturbance may be indistinguishable from those caused by landform and local variability in growing conditions, which makes it difficult to partition these two sources of ecosystem diversity. For example, two adjacent patches on an Alberta Vegetation Inventory map are separated if the height of the dominant trees differs by two or more metres (Government of Alberta 1991); the boundary between these two patches may be caused by disturbance, or by underlying differences in nutrient availability and other attributes affecting tree growth. Of these two sources of patch boundaries (disturbance and landform/site conditions), only one (disturbance) is expected to cause new patch boundaries over the short term; monitoring efforts should therefore be focussed on the identification of disturbance-generated boundaries.

This inability to distinguish between patches generated by disturbance from those generated by other factors limits the usefulness of many forest cover maps for long-term monitoring of ecosystem diversity. However, depending on the attributes associated with individual polygons, it may be possible to represent disturbance patches on a vegetation cover map by dissolving boundaries not associated with disturbance (Cumming et al. 1995a, 1995b). Patches generated by human disturbance, such as clearcutting, readily visible on most aerial photographs, are recorded on many vegetation cover maps.

In general, the utility of vegetation cover maps for monitoring changes in ecosystem diversity through time may be limited. In addition to the above difficulties, standards for the creation of vegetation cover maps may change through time (e.g., Government of Alberta 1985, 1991), and differences in the application of a single standard (e.g., interpreter bias) make it difficult to compare ecosystem diversity among locations.

5.2.2 Time-since-disturbance maps

Many studies have used aerial photographs to delineate boundaries caused specifically by disturbance (e.g., Tande 1979, Foster 1983, Rogeau 1996), and such data have been used in many temporal comparisons of ecosystem diversity (e.g., Romme 1982, Wallin et al. in press, Andison 1997). Standard methods for preparing time-since-disturbance maps (Fig. 8) are available (Arno and Sneck 1977, Lorimer 1985), many of which require extensive fieldwork to determine the year of origin for individual patches. In addition, only disturbances whose boundaries are visible from aerial photographs can be detected, so only relatively large, recent, intense disturbances (Baker 1992) are recorded. Thus, patches recently generated by natural disturbance can be more reliably identified than older patches.

5.2.3 Photo plots

A systematic approach to the use of aerial photos for monitoring CanadaÆs forests has been developed by the Canadian Forest Inventory Committee (Magnussen and Bonner 1997). The National Forest Inventory (NFI) will monitor changes within 4-km2 photo plots, arranged systematically over a network of locations 20 km x 20 km apart. Within each photo plot, forest cover polygons would be delineated based on vegetation composition and structure according to a standard protocol (Magnussen and Bonner 1997). Thee utility of this information for monitoring ecosystem diversity as defined in this paper may be limited due to the small size of each sample area (4 km2) relative to many natural disturbances. Boundaries of disturbance patches that that do not fall completely within a single photo plot would be incomplete, complicating measures of dimension and spatial arrangement. The system would be more effective for monitoring human-caused disturbances (e.g., Ripple et al. 1991), which are less variable in size, and generally smaller than 4 km2.

5.3 Satellite imagery

Satellite imagery has frequently been used to classify vegetation according to its structure, composition, and functional characteristics (Graetz 1991, Anonymous 1995). Among the many sensors available, LANDSAT is frequently used (e.g., Cohen et al. 1995), but many others are available (Franklin 1994, Cohen et al. 1996, Pitt et al. 1997). Depending on the sensor, it is possible to delineate patches generated by natural disturbance (e.g., Li et al. 1997, Flannigan and Vonder Haar 1986), and human-caused disturbances such as forest harvesting (e.g., Hall et al. 1991, Ripple et al. 1991, Spies et al. 1994, Cohen et al. 1995, Turner et al. in press, Zhang et al. in press). As with aerial photography, delineating older disturbance patches may be difficult (Nilson and Peterson 1994, Horler and Ahern 1986). An important capability of satellite imagery for ecosystem monitoring is the ability to observe differences between images obtained at different times (e.g., Fig. 9), to and quantify changes associated with disturbance (e.g., Fig. 10) (Cohen et al. 1996).

6 Measures of ecosystem diversity

6.1 Non-spatial measures

Provided the appropriate data are available, it is possible to report both spatial and non-spatial measures of ecosystem diversity. Non-spatial measures are generated by tallying the combined area of ecosystems having some common attribute such as a similar time since disturbance. Age-class distributions, and the total area of particular age classes (e.g. old-growth) are useful non-spatial measures, which may be stratified by broad land cover classes (Fig. 7) or finer-scale, landform-based patches (Andison 1997). At a national level, the Compendium of Canadian Forestry Statistics (Canadian Council of Forest Ministers 1997) summarizes national trends in area harvested, burned, and disturbed by other processes by terrestrial ecozone.

The four measures of ecosystem diversity suggested by the Canadian Council of Forest Ministers (1996) are all non-spatial, and a relatively broad interpretation of ecosystems was applied: 1) Percentage and extent, in area, of forest types relative to historical condition and to total forest area; 2) Percentage and extent of area by forest type and age class; 3) Area, percentage and representativeness of forest types in protected areas; and 4) Level of fragmentation and connectedness of forest ecosystem components. Road density is suggested as a ôproxy indicator for fragmentation (Canadian Council of Forest Ministers 1996:8).

6.2 Spatial measures

Spatial measures of ecosystem diversity may be further subdivided into three categories (Eng 1998): dimension of individual elements (area, perimeter, shape); composition of ecosystems within a landscape (abundance, diversity, edge density); and spatial arrangement (distances among ecosystems, including dispersion and contagion, measures of landscape connectivity). Collectively, these describe landscape pattern and structure (Forman and Godron 1986, OÆNeill et al. 1988).

Calculation of ecosystem diversity metrics facilitates the reporting of temporal trends within a region and allows comparison of trends among different regions (Eng 1998); the use of such metrics also facilitates retrospective descriptions of historical ecosystem diversity (e.g., Romme 1982, Reed et al. in press, Ripple et al. 1991), and forecasts of future ecosystem diversity under various disturbance scenarios (e.g., Wallin et al. in press). Unfortunately, the ecological significance of individual metrics is frequently unclear, and the response of species to landscapes with different values for a particular metric is unknown for virtually all species (Eng 1998, Garman and Bradshaw 1993, but see Romme and Knight 1982). Deciding which of the many available metrics is most important to report is also difficult (OÆNeill et al. 1988, Baskent and Jordan 1995). However, of the dozens of metrics available, OÆNeill el al. (1988) identified three (fractal dimension, dominance, contagion) that were best suited for discriminating among major landscape types in the eastern US. Ritters et al. (1995) found that a small subset of 55 metrics considered was useful in describing differences among US Geological Survey Land Use Data Analysis maps. This subset included average patch perimeter-area ratio, Shannon Contagion, average patch area, patch perimeter-area scaling, and number of land cover types.

As discussed in section 4.2, vegetation on either side of a disturbance patch boundary frequently

converges through succession towards a similar composition and structure, and the relative amount of contrast between adjacent patches may change through time depending on the characteristics of each. This has implications for measures of ecosystem diversity through time, because while new disturbance patches are added, the contrast between existing patches may change (Urban et al. 1987). For example, the contrast between two adjacent disturbance patches, one logged 5 years ago, and the other logged 15 years ago, may be greater than the contrast between the same two ecosystems 80 years later. In a simulation of landscape change in central B.C., Andison (1996:112) incorporated variable edge contrast by differentially weighting the length of edges between adjacent patches. For a more complete discussion of patch definition and edge contrast, see McGarigal and Marks (1994).

7 Reporting

If open communication of trends in ecosystem diversity is a prime motivation for a monitoring program, then the Internet is an appropriate venue for reporting. At the national level, numerous templates are available, such as the Canadian Environmental Indicator Series (http://199.212.18.79/ind/English/Home/default.htm), the Compendium of Canadian Forestry Statistics (http://nrcan.gc.ca/cfs/proj/iepb/nfdp/cp95/compen_e.htm) and the US National Environmental Monitoring Initiative (http://www.epa.gov/cludygxb/sites.html). Surprisingly, similar reporting mechanisms at the provincial or local scale are scarce; links with national initiatives would be an effective way to advance local reporting of ecosystem diversity.

8 Summary and conclusions

A coordinated approach would improve the probability that effective ecosystem diversity monitoring systems are developed and maintained (Committee on Environment and Natural Resources 1997). The National Forest Inventory (Magnussen and Bonner 1997) and the Earth Observation for Sustainable Development of Forests program (Goodenough 1997) represent two attempts to coordinate the acquisition and reporting of ecosystem diversity measures, and should be consulted by groups such as model forests attempting to monitor within smaller regions. In an increasingly global economic and social climate, the pressure on governments, industry, and other stakeholders to report on the status of ecosystems will continue to grow. Maintaining a focus on dynamic aspects of ecosystem diversity, such as disturbance patches and linear developments, would provide land managers and others with an improved capability to track changes in ecosystem diversity that are significant in the context of sustainable forest management.

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Species diversity and the use of species as indicators of forest change

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Introduction

The conservation of biological diversity at multiple scales has become an important consideration in forest management. With numerous species in ecosystems, any of which may indicate some aspect of the system, an important consideration is where best to focus monitoring efforts to ensure that biodiversity is maintained in time and space. The focus of this paper is species as indicators of change in forested systems.

One possibility in choosing indicators is to consider species that are important to ecological function at various scales. In an interesting paper, John Lawton (1994) posed the somewhat rhetorical question: "What do species do in ecosystems?" In a certain sense his question was trivial because without species there would be no ecosystems, but the question was important with respect to many species that apparently live on the excess energy produced in ecosystems with no apparent functional role. We could ask would removing Cape May warblers from boreal forests change the forests (other than reducing the neophyte bird-watcher's dilemma of distinguishing them from golden-crowned kinglets)? The answer is probably not, because like most neotropical migrants, Cape May warblers take opportunistic advantage of a seasonal abundance of available food resources in boreal ecosystems, and then leave when resources become impoverished. Do Cape May warblers provide some ecological service to the ecosystem or do they simply live off its excesses, and does this matter? I know the question may seem somewhat trifling, but in the choice of indicators of forest change it may be a reasonable question to ask. Species that are directly involved in system processes may make better indicators of forest change than those that are not. On the other hand, several authors have argued recently that ecologically redundant species make superior indicators to those that are functionally unique (Carpenter et al. 1993, Ives 1995, Bowers 1996). Their argument goes: the greater are a species' interactions with other species (i.e., the more connected it is within a system), or the lesser its functional role, the more it is buffered from changes within the system. Therefore, the more redundant a species is within a system, the better it is for indicating change. This is very much like the evolutionary geneticists' argument that genes that 'tag along' during selection events are better indicators of speciation than more functionally-linked genes. I am willing to sit on the fence with respect to the issue of whether functionally-linked species are the best indicators or not, because I do not see function as the only question relating to reliability of a given species as an indicator in forested systems.

Several hypotheses have been proposed to relate ecosystem function to species richness. These include (Vitousek and Hooper 1993, Lawton 1994): 1) a null hypothesis - where ecosystem function does not change with gain or loss of species; 2) idiosyncratic hypothesis - that predicts there will be a change in function related to species loss or gain, but the magnitude and direction may not be predicted; 3) the rivet hypothesis (Ehrlich and Ehrlich 1981) predicts all species contribute to function and loss/gain in function is equitable for each, or that thresholds in numbers of species exist that once crossed, a disproportionate amount of function is lost; 4) the redundant species hypothesis that predicts only some species contribute to function and the roles of all others are redundant (Walker 1992, Lawton and Brown 1993). There is little evidence to support any of the hypotheses, particularly for vertebrate species. However, as a general principle, theory and experimentation suggest that complex ecosystems with large leaf areas are more productive and maintain more niche space, hence more species, than less productive ecosystems with minimal richness in primary producers (Tilman et al. 1996, Tilman et al. 1997). However, rich systems are also likely to maintain a high species redundancy (Lawton 1994). Sugihara (1980) disagrees, and suggested communities form around a hierarchical niche structure ('sequential breakage model') that obviates any redundancy. Work by Tilman and Downing (1994) revealed that reducing the number of primary producers in field experiment in grasslands from 25 to 10 did not alter net primary productivity. Opposite results were achieved by Symstad et al. (1998) who showed a decline in plant biomass with species reduction, also in grassland systems. They found that N retention (a measure of productivity) changed unpredictably depending on the species removed, supporting the idiosyncratic hypothesis. A further

unknown is the role of rare species under extreme events in buffering the ecosystem against change (Schulze and Mooney 1993). For example, following the massive ice storm of last winter, will some rarer species (such as red spruce, for example) increase their productivity under reduced competition for light on some sites? The relationship between stability in systems and diversity is still obscure.

In animal communities, the relationship between productivity and species richness is not always clear (Rosenzweig and Abramsky 1993, Srivastava and Lawton 1998). At broad scales, there are latitudinal and longitudinal relationships between productivity and species richness for all groups of vertebrates in Ontario (Thompson in press). However, the particular mechanisms underlying observed relationships between productivity and species richness are several and varied: including energy limitation on the number of trophic levels, increased specialization with productivity, and multiple dynamic equilibria in productive vs less productive systems (DeAngelis 1994, Abrams 1995).

The point of this preliminary discussion is to suggest that there is great uncertainty about the roles that most species play in forested systems, and how we can explain species presence or absence. Some species are undoubtedly more important to function than others and may make good indicator species. However, while many species may in fact be redundant or net removers of energy from the system, this does not mean that only those with a functional role, such as keystone species or decomposers, need be considered as important indicator species. There are also a number of logistical and political aspects relating to selection of indicator species for a monitoring program.

Community assemblage

I use the term 'community' here to mean selected subsets of the plants and animals living together in a defined area at a defined time period. Because I do not mean *all* plants and animals at once, some people may prefer the term 'species assemblage', but I have used them interchangeably in this paper. At some scale, all communities are a subset of a larger species pool. However, in similar forest patches not all subsets of species necessarily are the same, and across landscapes habitats are not uniform. Variation in species diversity is affected by numerous biotic and abiotic variables. These variables can lead to wide disparity in species richness measures across samples from a landscape. Community assemblage depends to a large degree on history and stochasticity, as well as availability of suitable habitats, environmental gradients, and the supply of species through immigration. Numerous processes affect species' capacity to occupy a forest stand including competition for resources, and demographic factors. In studying the effects of change in forested systems, the concept of alternative states in the same forest types must be considered. In other words, the presence or absence of a species in an area may simply be a manifestation of the same community in a different state, with no change in its functional capacity. Further, under metapopulation theory, at any given time a patch of habitat may or may not be occupied by a certain species. Therefore, absence of an indicator species may indeed suggest problems, but certainty with respect to its absence can only come from a properly designed monitoring program that recognizes spatial variability in species abundance.

Local richness may be controlled ultimately by top-down, extrinsic large-scale factors, rather than by local processes, as suggested by Currie (1991) and Thompson (in press). Saturation of communities has relevance for conservation and the assessment of indicators. There is a well-documented species to area relationship, of the form $S = cA^z$, where z is usually about 0.25 (Preston 1962). The asymptote of the curve depends to a large extent or the beta diversity of the landscape. A high beta diversity will result in high regional diversity, but low local richness (Cornell and Lawton 1992). Harte and Kinzig (1997) derived an equation for determining z based on species turnover in space which is defined by sampling two blocks of habitat and examining the number of species common to the two patches. The constant z is proportional to (area of the patches/(distance between the patches)^2)^y. Once the constant is derived, the relationship between species richness and area becomes valuable for predicting numbers of species on a sample area, and possible changes as a result of perturbations such as forest management.

Species responses to environmental change

The use of species as indicators must be couched in the context of some reasonable hypothesis of effect. Hypotheses and their tests should be not be trivial, such as how a salamander community associated with old growth forest compares to that five years after clearcutting, or whether increased edge following logging has affected a species or guild. In McLaren et al. (1998), we suggested that a reasonable hypothesis was to compare numbers of a given species in natural and managed stands of similar type, size and age, over appropriate temporal and spatial scales and assuming no differences. Given that construct, one would want to maximize chances of success by choosing species for which an effect might be demonstrated.

Unfortunately the simple idea that a single species might make a good indicator of a particular forest ecosystem change, including correlated changes in associated species, is unrealistic. Reasons why this may be so include: niche theory predicts that no two species can occupy the same environmental space, and so changes observed in populations of one species likely do not represent changes in any other species; population regulatory mechanisms differ among species; cascading effects to change in a keystone species may affect the indicator; demographic stochasticity may affect species periodically and may be unrelated to habitat; and ecosystem processes may be unaffected by species loss (Verner 1984, Landres et al. 1988, Walker 1992). Taper et al. (1995) reported individualistic responses in population dynamics in forest birds to changes within and between areas. Using Breeding Bird Survey data, they found heterogeneous temporal responses of the same species within a strata, differing responses among species within a strata, and that much of the change was predicted by chance alone. Similarly, Niemi et al. (1997) showed inconsistent patterns of habitat use by forest bird species that had been chosen as indicators, few correlations of population changes among species, and high temporal variation in abundance that was inconsistent among species. In other words, species responded individualistically to change as is predicted by the unique niche hypothesis, suggesting that changes in numbers of one species do not necessarily correlate to changes in others. Animal species respond independently to habitat change.

Even where there has been a documented effect in an expected direction that seems correlated with factors that reasonably explain the change, the actual factor responsible for the change may be unclear, or correlated to the effects examined. Moose in Ontario have increased dramatically province-wide during the past 15 years (Rempel et al. 1997). Explaining cause and effect are is difficult in this particular case, and there are at least three possible explanations. First, rapid forest removal has resulted in considerably increased habitat availability over the past two decades; second, the climate has ameliorated over the current decade from that during the previous decade and has likely enhanced survivorship; and finally, the province instituted a selective harvest system in the late 1980's that reduced hunter numbers and their effectiveness, and forced hunters to concentrate in the least productive components of the population. Discovering the real reason for the observed increase in moose numbers is not simple, and any answer will certainly be open for debate. Tests of change using species as indicators must be constructed in such as way that cause and effect are certain. Otherwise, responding through adaptive management may lead to a nil response by the species or groups of species.

Species as indicators of what?

How do we reconcile the need for indicators, that has been forced on forest managers by various political processes, and the arguably ineffectual value of indicator species to suggest that change has indeed occurred? The answer to this question addresses the future role that species indicators may play in forest management.

What are we really trying to show with indicator species? The concept of indicators has to be more than simply that a change in ecosystem function translates into a change in numbers of the indicator. Forest ecosystems, forests stands, and forest landscapes are comprised of communities of plant and animal species in a hierarchical fashion. If we were looking for the effects of say some chemical on biodiversity, for example phosphamidon used to kill budworm, then counting any one of a number of pollinators, or even certain warbler species, might be sufficient to indicate an effect. However, we are not looking for a point source effect, rather we concerned about changes to forests in terms of their structures and functions at scales from a few square

metres to hundreds of square kilometres. So, while we should be concerned about individual species from a conservation perspective, what we are actually concerned with is changes to the communities of species.

Hunter (1990) suggested that indicators were species that should be monitored to indicate the presence/absence of certain specific conditions or structures that were missed with coarse filter (or forest type) management. This is a very narrow use of the term 'indicator'. While some species may be particularly good indicators of a given structure, I suggest that we should look beyond the single species - single structure concept, if indicators are to become a useful tool in forest management monitoring and adaptive management. There is a substantial literature with respect to community responses as indicators of pollution effects (e.g., Cairns 1985), but in forested systems, agencies have concentrated on individual species' responses to habitat alteration. If forest processes have been altered, then the structure of animal communities will likely also have been affected (Holling 1992). It makes sense then to examine species assemblages as indicators, rather than trying to monitor individual species because the latter focus too narrow and because of the general lack of autecological information (Kremen 1992, Dufrêne and Legendre 1997).

It is important to recognize that indicators are monitored to suggest change in habitat or function, with a view to altering management regimes as a result (Noss 1990). This is not the same as managing for species or groups of species, and a criterion of selection of indicators is that they ought not to be managed species (see below). Indicators may be employed to assess change in a long list of forest aspects including processes and structures from sites to landscapes. For example we may be concerned with landscape heterogeneity, or site diversity.

Communities of species as indicators

Species that occupy a wide range of micro-habitats and have a range of dispersal capabilities would be expected to show a greater range of sensitivity to forest ecosystem change than individual species (Terbourgh 1974, Kremen 1992). The coexistence of species is affected by behavioural mechanisms (temporal separation, spatial separation), as well as occupancy of non-overlapping niches. Some species may be generalist is their use of habitats, while others may be more specialized. However, even generalist species may be specialized at scales. Monkonnenen and Welsh (1994) hypothesized that conifer generalist resident birds such as boreal chickadees, may be specialists at the landscape level, seeking out expanses of suitable mature forests. Effects of forest management may affect a community of species at a range of scales from site to landscape and any analyses should reflect that concept.

Selection of communities or species assemblages to monitor should consider their sensitivity to forest change at scales relevant to the problem. Westoby (1998) noted that it is important to choose the appropriate scale for assessing local species richness, and because the analysis is statistical, an adequate number of points with which to perform regressions must be obtained.

For many groups of species, animals or plants, all (or most) species in an area may be sampled simultaneously depending on the method used. Discarding the broader data set in favour of a few chosen species is not cost-effective when the tools are available to use all data. For example, theoretically all songbirds can be recorded in singing male point counts, all salamanders may be equally vulnerable to pitfall trapping, and small mammals species are all readily captured in snap traps combined with pitfalls. Many of these data sets lend themselves to community analyses regardless.

Statistical approaches

Any monitoring program needs to consider control sites and effects sites as part of a proper study design under the null hypothesis. However, what constitutes a control is open to debate and a monitoring program must be able to establish cause and effect. In a perfect world, an undisturbed area would be compared to a disturbed area, as is done routinely in experimental biology. I would argue, from biological and philosophical perspectives that forestry is an experimental procedure, and exactly what constitutes a suitable 'control' needs serious

consideration. We will only begin to see the real answers to the question of ultimate effects of timber harvesting when areas that were logged mechanically (i.e., since the early 1960's) become old forests in another 30-100 years in boreal forest systems, depending on the forest type, and in another 500 years or more in temperate rain forests. The question of adequacy of controls is scale dependent. For monitoring programs at the site, stand, forest, or landscape level, controls must be sought in areas that have developped naturally following disturbances such as fire and windthrow. In other words, a proper comparison under a null hypothesis that forest management does not differ from natural disturbances should be carried out in areas of the same original stand types, that have developped new forests following natural disturbance and logging, and where the same amount of time has passed on each area. Clearly the greater the scale of the question, the more difficult it will be to adequately achieve adequate controls for the monitoring program, particularly since replication is important.

A number of multivariate methods are available to ordinate communities and to group or cluster species in a rigourous fashion. Further, bootstrapping techniques are now available with many ordination programs that can be used to more rigourously assess results. Ordination techniques allow visual exploration of species community associations (Gauch 1982). Detrended correspondence analysis (DCA), and more recently canonical correspondence analysis (CCA) (ter Braak 1994), are commonly recommended tools for ordinating sites and species against environmental gradients. An advantage of CCA is that it provides a visual display of important variables that have affected species distributions on the axes, as well as the relative strength of the variables. Typically, rarer species occur towards the edges of ordination diagrams (ter Braak and Prentice 1988), while groups of species that associate with similar environmental conditions occur close together. Although rare species may be stenotopic and make reliable individual indicators of some habitat or structure, they may provide little information to the ordination axes (ter Braak and Prentice 1988). However, where a rare species is only or primarily associated with one of the major axis variables its location in the ordination may provide valuable information about the community. Ordinations are usually accompanied by some hierarchical clustering techniques to group species (Figure 1). The value of ordination procedures is that they allow the treatment of community data, enabling visual examination of comparisons among communities and the choice of indicator assemblages. Predictive power from an ordination is limited by the representativeness of the sampling design (Dufrêne and Legendre 1997), however this is generally not a problem when dealing with stand level or forest level communities.

Ordination of communities can aid in decisions about which communities might perform well as indicators, or suggest the properties of a particular group of species as indicators at a given scale. The pattern of co-variation among species may indicate impacts of effects. Included here are two examples where my co-workers and I have used CCA to examine species distributions in forest ecosystems. The first (Figure 2) is an illustration of an ordination of the forest songbird community in western Newfoundland, taken from (Thompson et al., in press). Our interest here, lay in the question of whether or not truncating the age class distribution of balsam fir forests by moving to a 60-year rotation would influence biodiversity in these forests. The ordination clearly identifies a group of old-forest species, some of which were rare, that made strong indicators of old balsam fir forests. On the other hand, carabid beetles do not appear to be strong indicators of forest condition between mature age classes of white pine forests, or to distinguish pine from boreal-type mixedwoods in central Ontario (Figure 3) (Applejohn et al., in prep.). While the stands clearly separated along axes 1 and 2, most of these beetle species were highly general in their selection of the forest types. Our result was contary to those of others working with carabids along more dramatic or obvious gradients, such as edges or fragmented landscapes (e.g., Luff et al. 1992).

If ordination suggests that the chosen community could indicate effects, and if alternative hypotheses can be obviated, then tracking the community can be done by sampling over time. In the Newfoundland example above, the presence of black-backed woodpeckers, grey-cheeked thrushes, coupled with observed declines in densities of other species such as boreal chickadees, that were sufficient to result in a clear separation among ordinated groups of birds, could be used to suggest forests had aged sufficiently to contain old growth

characteristics.

TWINSPAN has been a standard method of identifying groups of species that respond similarly to environmental influences (Hill 1979). Because TWINSPAN uses pseudospecies with which to associate species and sites, rare and abundant species receive the same weightings (Dufrêne and Legendre 1997). Belbin and MacDonald (1993) criticized the TWINSPAN procedure on other grounds: it assumes a strong gradient dominates the data structure and ignores secondary gradients, and sites that may actually be close in species composition may be separated because of the way the method assigns groups. Recently, Dufrêne and Legendre (1997) have offerred an alternative called IndVal that has been included in the general multivariate package called PC-ORD (MjM Software, Gleneden Beach, OR, USA). This method uses the proportional abundance of a given species in a particular group, such as in a given forest site, relative to the abundance of that species in all other groups, and then looks at the percent of sample units in each group that contain that species. Those two proportions (relative abundance, and relative frequency of occurrence) are then used to derive an indicator value for the species. The advantage of IndVal over TWINSPAN is that IndVal index values are independent of the relative abundances of other species, and it does not employ pseudospecies. However, both methods provide a strong mathematical basis on which to suggest community structures as indicators of change.

Richness or diversity indices

Ecological communities have been characterized by diversity indices as a technique to express relative diversity among treatments and a s means to suggest changes in a system as a resulting from stressors. There are numerous indices of diversity and species richness, but their usefulness in terms of information is suspect. These indices usually vary non-linearly with the sampling unit and the size of the study area, making them unreliable (He et al. 1994). Some of these indices are subject to biases from over- or under-weighting rare species, and they tell us nothing of which species are present or absent. Diversity values from two sites may be identical but based on an entirely different array of species. Further, high or low diversity does not necessarily reflect high ecological importance (Dunn 1994). Green (1979) discouraged the use of derived indices to indicate environmental change on empirical grounds, suggesting that multivariate methods are more appropriate because they maintain more biological information. Comparing areas treated and untreated with fenitrothion, Kevan et al. (1997) found Shannon-Weaver and Jaccard indices failed to distinguish among states. Diversity indices should be regarded simply as a tool for comparing alternatives (Hunter 1990).

Species abundance models - Log-normal distributions as indicators

Although species abundance models have been suggested for many years, their usefulness in prediction of community change has not often been suggested, and considerable work remains to be done in this area (Tokeshi 1994). To use these models, the community must be sufficiently sampled that only relatively a small amount of the distribution remains hidden behind the 'veil line' (Hill and Hamer 1998), and communities with small numbers of species (e.g., temperate forest bats) are inappropriate for consideration.

Log-normal species distributions have been suggested to indicate communities in equilibrium, and that departures from the distribution would mean changes have occurred as a result of some perturbation (Stenseth 1979, Sugihara 1980, Preston 1980, Hill et al. 1995, Hamer et al. 1997, Kevan et al. 1997). Some authors have stated categorically that a log-normal species distribution can be used to indicate disturbance to 'ecosystem health', or environmental disruption, largely because it combines information about diversity and abundance (e.g., Kevan et al. 1997). Unfortunately, the published tests of variance from log-normal models pertaining to forested systems have all used trivial examples, such as cut vs uncut treatments (Hill et al. 1995, Nummelin 1998).

Forests may never be in equilibrium at any scale, and Suffling (1995) suggested that forested landscapes are in constant disequilibrium over long temporal scales. Further, similar to the above criticisms of diversity indices, species abundance models also conceal important information on which species are abundant and which are not. Species abundance models may have merit in distinguishing natural functioning systems from systems

that have either moved to another state, or have not recovered, but I have seen no published test of this hypothesis for forests.

Species accumulation functions

Several models exist with which to predict total species based on number of species detected in a survey. Rarefaction models (e.g., Krebs 1989) have been employed for many years to suggest upper limits to species richness. Soberon and LLorente (1993) reviewed three species accumulation curves where sampling time was the independent variable: Clench equation, exponential, and logarithmic curves. This approach has not received wide attention from conservation biologists, but the results from Soberon and LLorente suggest that the approach has merit in certain situations: for example, when comparing species presences among landscapes where temporal restrictions apply.

Choosing individual species as indicators

Although I have argued here that animal (or plant) communities will make the best indicators of sustainable forestry, many agencies will prefer to find a small number of individual species to use as forest indicators. In a mechanistic paper, McLaren et al. (1998) described the process used in Ontario to select individual indicator species for a forest monitoring program. Consideration was given to three main criteria: biological, methods, and legal status (Table 1). The biological criteria established a framework for the choice of species based largely on their responsiveness to forest management. The methods criteria ensured that selected species were relevant to the working hypothesis (natural vs. logged sites are the same) and monitoring techniques existed. The status criteria provided several guidelines with respect to 'value' and importance of the species within Ontario; obviously the species selected under this criteria would differ by political jurisdiction. They viewed these criteria as hierarchical in their importance: biological > methods > status. McLaren et al. (1998) used a relative few broad habitat (forest) types for which to choose vertebrate indicators to simplify their problem, as well as three scales: stand, forest, and landscape for each forest type. A list of 40 species in the boreal forest, and 48 species in the Great Lakes-St. Lawrence forest were selected for monitoring in Ontario. The example from Ontario is presented here to provide a framework that seemed to work in reducing the large number of species that could be selected as indicators to a relative and manageable few. Many of these criteria are also applicable to the selection of communities to be monitored

Table 1. Three levels of criteria used for the selection of species as indicators of sustainable forest management in Ontario (from: McLaren et al. 1998).

A. Biological Selection Criteria
   1. Species is dependent on forest habitats.
   2. Species is responsive to forestry practices.
   3. A range of body sizes/home range sizes should be represented.
   4. A range of life history strategies should be represented.
      - 4a. All trophic levels should be represented.
      - 4b. Year-round residents should be given priority over migrants.
      - 4c. Include habitat specialists and generalists.
   5. Biologically rare species should be selected, particularly if their rarity is habitat-related.
   6. Species should indicate a range of forest habitat types and structural characteristics.
   7. All known keystone species should be selected.

B. Methods Selection Criteria

1. The species must contribute to testing the hypothesis.
2. A sampling protocol must be available.
3. Species should be distributed so that a statistically valid sampling is possible.
4. Sampling should be cost effective.
5. A control area, where populations are determined by natural factors, should be incorporated as part of the sampling design.

C. Status Selection Criteria

1. Provincially or regionally featured species must be monitored.
2. Species has a low or diminishing habitat availability at the ecoregional scale.
3. Species is one for which Ontario bears a high level of conservation responsibility.
4. Species is easily recognizable by the public.

Conclusions

The indication of forest community change (or stability) is a multivariate problem requiring the census and ordination of communities at various appropriate scales of space and time. Individual species may be used to indicate certain structures or perhaps even habitats, however, forest management may alter entire communities. Further, communities are likely more sensitive to change than are individual species because a individual species within a group may be affected by different aspects of change such as different processes, or structural habitat components. The availability of multivariate statistical packages with monte carlo and bootstrapping techniques to test significance now makes community ordination an accessible technique. Certain information statistics such as models of abundance and distribution are worthy of investigating to determine their value as indicators of change.

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Genetic Diversity: Indicator Selection and Assessment

Judy Loo

Summary

I present a brief overview of the meaning and importance of genetic diversity before addressing measurement issues. Indicators of genetic diversity fall into several categories which can be summed up as: management based, process based, and direct indicators. Management based indicators are used to monitor human activities related to gene conservation. Process based indicators are intended to facilitate monitoring the genetic processes that maintain adaptive potential. Direct indicators deal directly with genetic diversity of selected species. I argue that process based indicators are the most useful.

Genetic Diversity Defined

Genetic diversity is inherited variation within and among individuals within species. It is the result of differences in gene coding, caused by mutation, and maintained in populations by selection, migration, and chance. Most genetic variants are deleterious, causing an enzyme system or other protein component to malfunction. Other variants may be neutral under current conditions, acquiring a positive or negative value if particular conditions change. Occasionally mutations that give rise to variants are particularly adapted to current conditions conferring selective advantage.

Genetic diversity exists both within individuals and among individuals. Higher organisms have two or more copies of each strand of DNA, but the copies are not identical. Thus at each gene locus, or matching locations on DNA strands, there may be different forms of a gene which code for different expressions of the same trait. As an easy (and simplified) example, consider eye color in humans. If one parent had brown eyes and the other blue, chances are good that the offspring will have two forms of the gene at the eye color locus. In this case, brown is dominant to blue so the eye color in the offspring would be brown. For species that interbreed, like humans, and most trees, a lack of genetic diversity within individuals generally implies inbreeding.

Each individual organism of the higher species has thousands of gene loci. Add to this the fact that there are often more than two forms of a given gene (though no more than two in a given organism), and the stage is set for endless combinations of genetic variants among individuals within a species. The plethora of genetic

variants arising through mutation and distributed by interbreeding of individuals, is maintained and shaped by three population-level processes. These processes largely direct the course of evolution, at least during periods between catastrophic occurrences. Selection is the process by which genes conferring selective advantage under current conditions are accumulated in populations. Migration is the movement of genes among populations allowing genetic variants with new adaptations to gradually become established over large areas. This process is necessary for avoiding eventual inbreeding and concomitant loss of diversity particularly in small populations. Migration can have a counter-adaptive effect as well, effectively slowing down the rate of local adaptation occurring in response to localized environmental conditions, if the rate of migration overwhelms the selection pressure. Though chance is often overlooked, it may play a large role in determining which variants remain in a population, particularly when populations are small.

Why Genetic diversity?

Genetic diversity is the most basic level of biodiversity, yet it is the most commonly ignored, the least understood, and the least often measured. Time and again I have heard that it is too complicated or too difficult to do anything about biodiversity at this scale.

Before presenting my thoughts on selecting, measuring or monitoring genetic diversity indicators, I am going to revisit the question of why conserving, and thus measuring and monitoring genetic diversity is important. The world is changing, rapidly. Some of the changes are natural; we live in a world in which change is a constant. Many of the changes in temperature, precipitation patterns, soil fertility, habitat patch size and configuration, ecosystem type, atmospheric composition and other environmental conditions are human caused. For the purposes of this discussion, the cause of change does not matter, except to note that the human-induced changes are happening at a faster pace and broader scope than most natural ones.

We have all heard the argument that changes are too rapid for adaptation to keep pace, thus vulnerable species are doomed, regardless of their potential for gradual adaptation. The argument holds that under these conditions, genetic diversity, as the ôstuff of evolution will be irrelevant. That may be true, depending on the factor that is considered at the time. But there is mounting evidence that evolution has not always happened in a smooth continuous fashion. For example Gould (1989) noted that there are two situations under which evolution may occur: normal (gradual) circumstances, and post catastrophic. Current thinking holds that historical catastrophic events may have been followed by ôbursts of evolutionary change. This means that most individuals of a species may be wiped out, leaving only those anomalous ones having ôpre-adapted traits that allow them to survive the particular environmental insult. Some species go extinct opening new opportunities for expansion of the remaining species into previously occupied, or radically changed niches. Of course a ôburst in ôdeep time is still a long time in terms of our lifetimes.

Pre-adapted variation refers to the existence of random variants that, by chance, have genetically controlled characteristics predisposing them to survive a particular shift in biotic or abiotic conditions (Ledig 1986). Large, genetically diverse populations of any species maintain a plethora of variants, some of which are advantageous in the present environment, many of which are presumed to be neutral, and some that are mildly deleterious under present day conditions. Given the state of todayÆs technology, it is impossible to predict which variants may become important in a different environment. In the face of rapid and catastrophic environmental change, resulting from high CO2 levels, import of exotic diseases, parasites, herbivores or predators, widespread loss of forests, desertification, or changing temperatures, survival of species may depend upon the existence of particular pre-adapted variants in existing populations.

Lest this seems too esoteric, let me give an example. As we all know, butternut is succumbing rapidly to a disease that presumably was introduced to North America more than two decades ago. The vast majority of infected trees, die within a few years and almost all trees within the area where the disease has spread have become infected (Prey et al. 1996). Butternut may be doomed unless pre-adapted variants, having resistance to

the disease, exist within one or more populations of the species. There is some evidence that this is the case, and work is underway to find and propagate these variants. In this case, if resistance exists within the species, it may be conferred by a single gene with a highly specific resistance to the pathogen. Or it may be conferred by an accumulation of small effects coded by several genes, and may not be recognizable as a single mechanism in all resistant individuals. This is the more durable and desirable resistance. In either case, the incidence of resistance, if present, is very low and the genes responsible exist at a very low frequency. Without large, genetically diverse populations, the probability of survival of a species when presented with a challenge of this magnitude, is low.

Genetic diversity is necessary to allow evolutionary processes over the long term, whether or not widespread catastrophic changes occur. Sufficient genetic diversity must exist within populations to ensure the potential for adaptation to gradual change. In addition, potential future economic value of variants is unknown but it would seem prudent to maintain as wide a variety as possible. As markets change in unpredictable ways, previously ignored variants may suddenly be valuable (Ledig 1988). Stability of populations and ecosystems may depend on genetic diversity (DeWald and Mahalovich 1997) in so far as genetic diversity buffers populations in the face of unpredictable environmental changes.

Finally, there is ongoing debate about whether we are essentially wasting our time in addressing problems at the genetics level when global biodiversity faces such large scale problems. Clearly genetic analyses and gene conservation measures are not the answer to the problem of destruction of the rainforest. Yet, as summarized by DeWald and Malhalovitch (1997), if appropriate genotypes are not available, provision of adequate habitat will not save a rare species. After other factors are addressed, the role of conservation genetics and application of genetic diversity to degraded areas may be an important component of restoration, but in the meantime, too much will be lost if we ignore genetics until other problems are solved.

Measurement

There are a number of direct and indirect measures of genetic diversity, none of which is ideal for monitoring indicators. The most common method for estimating the level of genetic diversity in a population or species is by using ôisozyme analysis. This is a technique for measuring the diversity among functional forms of common enzymes. Genes code for the protein strands that constitute the enzymes, so enzyme diversity is considered to be close to the actual genetic diversity. The enzyme forms are generally equally functional as far as is known, so this analysis considers the diversity of neutral genes in the absence of selective forces.

Other, more recently developed analyses examine variability in the genetic code itself. This may be problematic if the researcher does not know what kind of DNA is being examined. Large proportions of the genomes of many species appear to be non-coding as far as scientists can tell. Diversity in the non-coding areas is assumed to be neutral with respect to selection, but it may give an inflated view of the actual genetic diversity because there is no reason for the genetic code to be conserved within a species if it does not code for a functional protein.

The old method of evaluating the genetic variability within a plant species is by ôcommon garden experiments. This includes provenance trials and progeny tests. There is still much to be said for this approach. Though it provides a less precise estimate of the genetic diversity because of the ôdistance from the gene to the expression, the observed variation is known to have meaning in terms of the growth and survival of the organism. Disadvantages of common garden experiments are cost and length of time required for evaluation. Of course, cost is a consideration for any of the methods. Hence little data has been collected to date relative to the wealth of genetic information held in even one species.

The processes that maintain genetic diversity may lend themselves to monitoring more readily than genetic diversity itself. For example, selection will follow the vagaries of the natural environment unless it is influenced by human activities. Tree species may be monitored to ensure that harvesting practices are not

imposing artificial selection pressures on populations. Migration is influenced in a variety of ways including the effects of moving seed sources and planting non-local stock. Forest fragmentation influences migration, by creating barriers for some species but removing barriers for others if extensive land clearing has occurred. The relative influence of chance depends largely on size of interbreeding populations.

Indicators

The question of appropriate indicators of genetic diversity has proven to be one of the more intractable in the realm of biodiversity measures. While diversity is clearly important, it is both undesirable and impossible to preserve every gene of every species. Indicators that have been proposed to monitor genetic diversity may be categorized as management based, process related and direct genetic indicators. Management based indicators are used to monitor human activities related to gene conservation. Process based indicators are intended to facilitate monitoring the genetic processes that maintain adaptive potential. Direct indicators deal directly with genetic diversity of selected species. Table 1 lists a selection of indicators from a variety of sources that relate to genetic diversity.

Aside from the type of indicator (direct vs. indirect), there are other differences among the proposed indicators. For example, some are primarily concerned with endangered species. The term ôendangered has specific meaning and is limited to a small number of species, in which the gene pool has generally already been severely eroded. One might argue that the time for gene conservation is much earlier. CCFM focuses on endangered and commercial species. Species that may be most negatively impacted by human activities are not necessarily the commercially important ones, however. The apparent meaning, or function of the indicators varies as well. Some of the indicators, like the original CIFOR one are presented as directives, while others, for example the indicators proposed by Namkoong et al. (unpubl.), are value-free.

Approach to genetic indicators in the Fundy Model Forest

The Fundy Model Forest biodiversity group adopted the one CCFM indicator and added a second direct indicator of genetic diversity. The FMF group realized that at the moment there is really nothing to monitor with respect to the CCFM indicator. Until gene conservation strategies are developed, they cannot be implemented. Though there are elements of gene conservation strategies in place, these elements have never been identified as such, and indeed the primary purpose of these elements has not been gene conservation.

A working group consisting of a range of scientists, academics, and practitioners has come together in New Brunswick to assess the status of tree and some shrub species and to develop gene conservation strategies for those needing special attention. The Fundy Model Forest has provided some funding for that effort. In brief, the process for strategy development is as follows:

Develop criteria and rating system by which to evaluate the need for gene conservation measures. Assess the current status of tree and (some) shrub species including distribution in New Brunswick, regeneration potential, effects of usual forest harvesting methods, genetic diversity, population structure if known, and threats to long-term viability. Assess the current conservation status, i.e. presence of seed or other tissue with regenerative potential in ex situ conservation facilities and coverage of the species by in situ protected areas. Determine whether conservation measures are adequate, and recommend specific actions to meet additional gene conservation needs, in terms of seed collection (locations and amount) and in situ protection of populations.

The Fundy Model Forest partnership consists of a variety of landowners and other interests. As with any other management recommendations, no single body has the authority to require the other landowners to follow the strategies and plans that will be developed. The only way to encourage this is by ensuring that the various interests are represented throughout the process and that all landowners have an opportunity to contribute to the status assessments and the strategy development.

The other indicator involves monitoring populations of particular species. Proposed species include red

spruce and American beech. Red spruce is an important commercial species in the area and is sensitive to the dominant harvesting practices in the region. Almost all beech in the area is infected by beech bark disease which has serious economic and ecological consequences.

Recommendations

This summer, I participated in a test of criteria and indicators in the state of Idaho, sponsored by the Centre for International Forest Research. The only genetics indicator that I was asked to test was from CCFM: ôImplementation of genetic conservation strategies for endangered and commercial species. I found that though many of the components of what I would consider to be an adequate strategy for gene conservation were in place in the study area, there were no written strategies as such. Thus the indicator, taken literally would result in a ô0. In addition, I determined that the tree species of concern in Idaho are not necessarily either listed as endangered or commercial. In the wider context, even if a strategy exists, there is no standard for what constitutes a strategy. For example, a strategy may or may not have research behind it. It may be based on ôbest guesses, with little critical thought or it may be based on well-thought out, well-researched status reports. Thus in the testing process, this indicator was rejected.

The indicators that were chosen to replace it were process based and stated as directives (Table 1). The first relates to population size and the reproductive success necessary to maintain genetic diversity.

Table 1. Genetic indicators proposed by selected Criteria and Indicators Processes.

Source	Criterion/Element	Indicator
CCFM	Genetic Diversity	Implementation of in situ / ex situ genetic conservation strategy for commercial and endangered forest vegetation species
Montreal Process	Genetic Diversity	a) number of forest dependent species that occupy a small portion of their former range b) population levels of representative species from diverse habitats monitored across their range.
Helsinki	Maintenance,conservationand appropriate enhancement of biological diversity in forest ecosystems	Changes in the proportions of stands managed for the conservation and utilization of forest genetic resources (gene reserve forests, seed collection stands, etc.); differentiation between indigenous and introduced species.
Amazon Cooperation Treaty	Conservation of forest cover and of biological diversity	b. Measures of in situ conservation of species in danger of extinction c. Measures for the conservation of genetic resources
African Timber Organization	The main ecological functions of the forest are maintained	If enrichment plantings are carried out in logged over forests, preference will be given to species that were actually harvested in the forest.

Source	Criterion/Element	Indicator
FSC	Environmental impact	Ecological functions and values shall be maintained intact, enhanced or restored, including : b) Genetic, species and ecosystem diversity.
CIFOR	Impacts to biodiversity of the forest ecosystem are minimized	Enrichment planting, if carried out, should be based on indigenous, locally adapted species
CIFOR (proposed)	Conservation of the processes that maintain genetic variation	1. Levels of genetic diversity 2. Directional change in gene or genotype frequencies 3. Gene migration between populations 4. Mating system processes 5. Preventative or restorative actions are feasible
CIFOR (proposed at Idaho test)	ecological Integrity	1. Population sizes and reproductive success are adequate to maintain levels of genetic diversity. 2. Use of scientifically-basedseed transfer rules and seed orchard zones in planting native species. 3. Harvesting does not significantly change gene frequencies.
Fundy Model Forest	Genetic Diversity	1. Implementation of an ex situ / in situ gene conservation strategy. 2. Changes in population, genetic diversity and structure and gene flow for selected species.

Namkoong et al. (unpubl.) discussed population size as a verifier for genetic diversity. They pointed out that effective population size is a recognized indicator of the changes that lead to reduced genetic diversity. The estimation of effective population size is difficult, however, particularly where populations are heterogeneous in terms of age structure. Estimates of numbers of mature individuals, presumably contributing to the mating pool, are much more easily acquired from inventory data. The use of simple population size of mature individuals instead of effective population size necessitates increasing target numbers several-fold because the assumptions that mating is random and all mature individuals have equal opportunity to contribute genes to future generations are rarely true in nature.

Ledig (1992) pointed out that most harvest practices still result in dramatic swings in population size and age class structure. Leaving low numbers of parents in a seed tree cut may be result in elevated levels of inbreeding reducing survival, growth and fecundity of the offspring. In addition to ensuring that population size is sufficient and that the population achieves reproductive success, as indicated by surviving natural regeneration, density of seed trees retained after a partial cut, must be sufficient to avoid increasing natural inbreeding level.

This principle applies to plantations as well as natural forest. From the perspective of long term

sustainability, it cannot be assumed that plantations will always be followed by plantations, thus the genetic composition of the plantations must be sufficiently diverse and locally adapted to result in viable natural regeneration. When genetically improved material is extensively planted, buffers separating plantations from natural populations of the same species will protect the genetic diversity of these populations.

The second proposed indicator refers to migration, in the sense that tree planting constitutes human-mediated migration, and may have negative consequences for local adaptation. Local adaptations arise in heterogeneous environments and even a low rate of migration of maladapted genetic material may negatively impact local populations, depending on the strength of natural selection. Ledig (1996) pointed out that defining seed transfer rules is one of the most important tasks in conserving and managing forest genetic resources. Seed transfer rules and use of seed orchard planning zones are designed to reduce the possibility of planting maladapted trees that may contaminate local populations when they reach reproductive maturity. This is especially important in areas where natural populations may be small and large plantations could provide sufficient pollen to genetically swamp local populations.

Maladapted genes would be expected to be weeded out in time through natural selection if local populations of sufficient size remain, and the relative concentration of migrant genes declines, but losses of adaptive gene complexes could be incurred in the interim. Natural selection pressures for local adaptations may not be continuous; for example an important local adaptation may be for the 20 year frost event or a similar drought event. Thus genetic swamping of local populations coupled with overstory removal of the naturally regenerating forest could result in substantial losses of locally adapted gene complexes in the offspring.

The third proposed indicator relates to selection as influenced by harvesting practices. The potential for changing gene frequencies through harvesting activities is ever present, regardless of the method used. High grading is the term commonly used to describe the genetic consequences of selective removal of the best trees over several generations. Gene frequency change may be induced intentionally or unintentionally, through other forest practices as well.

When there is little advanced regeneration, and only poor quality, slow growing trees are left after cutting, dramatic changes in gene frequency for quality traits may occur (M.F. Mahalovitch, pers. Comm.). Ledig (1992) suggested that the pitch pine (Pinus rigida Mill.) form and growth rate that is commonly observed today may be the result of high grading over three centuries. ôEugenic harvesting practices favoring the fast growing and well formed trees may change gene frequencies in the other direction and may unintentionally influence gene frequencies of associated traits. To mitigate these effects, reserve areas well buffered from managed areas, where trees are not selected in either direction, will maintain the ônatural gene frequencies, if the populations are large enough to avoid effects of genetic drift and migration.

Harvesting practices can change gene frequencies, when rotations are very short, by preventing late maturing individuals from successfully reproducing. Gene frequencies may also be shifted by harvesting in a way that does not match the normal successional status of the harvested species. For example, clearcutting shade tolerant species selects for individuals that perform best in full sun, as partial cutting shade intolerant species would select for those individuals that can grow relatively well partial shade.

Namkoong et al. (unpubl.) proposed ôDirectional change in allele or genotype frequencies as an indicator of genetic sustainability. They argued that in addition to the conscious selection that occurs in a high grading situation, indirect selection effects may also result from correlations between traits. Another indirect selection effect could result from dependency of another species on a certain size or age class of the targeted species.

If genetic information is available, direct assessment of the influence of harvest on gene frequency changes could be carried out. Otherwise, the assessment would be done by determining whether high-grading is occurring, whether harvesting methods match the silvics of the harvested species and whether rotation lengths are adequate to ensure that all trees have an opportunity to contribute genes to the next generation.

Proposed Evaluation Procedures

In evaluating genetic indicators, first the target species and populations must be identified. In general the species that are chosen should be sensitive to forestry practices that are being carried out or other human induced perturbation in the region. Likewise for the choice of populations: they must be located in areas where the effects of the identified disturbance are occurring.

The choice of species for assessment should not be limited to those for which the most information is available but instead should be based on an evaluation of the likely effects of past and present forestry practices on the native tree species. This could be done as follows:

Categorize species including those with little or no commercial value, according to silvics and habitat requirements; eg. shade tolerant, shade intolerant, moisture requirement, etc.; and by range and frequency reduction or expansion in study area compared to reference (historical) levels.

List forestry intervention methods including proportion of study area treated by each method, and predict impact on the basis of silvics, habitat requirements, range and frequency of the species. Identify any additional human-caused or naturally occurring environmental changes that may be impacting populations of forest species. Check with local experts.

Identify those species that are expected to be impacted by the forestry practices.

Considerations in determining whether or not the evolutionary potential of a species is impacted by forestry practices:

Is the range or frequency of the species decreasing? Have populations become isolated?
Does the cutting practice suit the silvics of the species; e.g. does the predominant harvest method provide for the shade conditions required by the species?
Is regeneration adequate to maintain population size?
Are sufficient numbers of seed trees left on site (at least 10 per acre) to avoid inbreeding?

Among those species that are known or suspected to be susceptible to genetic change as a result of forest practices, choose several representing different impacts. For example, the assessor might choose one species that is undergoing intensive selection in a tree improvement program, one or more species of little commercial value that have substantially declined in the study area, and one or more species that do not respond well to the prevalent harvesting practices.

Indicator 1 (Population size):

Much of the required information should be available from standard inventories. Sampling must be done in reference populations as well as those impacted by forest harvesting. Reference populations should be managed to reflect natural condition as much as possible. In most areas, this means no active intervention. In fire prone areas, it means management allows or even sets fires to maintain the species and habitat conditions natural for the site.

Permanent sample plot data in combination with aerial photo interpretation can be extrapolated to estimate population numbers of tree species in various size classes, including established regeneration, per unit area. Data collection could be modified to include any other forest vegetation.
If possible, actual genetic diversity parameters should be measured and monitored over time for all commercial species and others of special concern. It is especially important to initiate comparative genetic diversity monitoring when population sizes are declining.

For species with declining populations, monitor genetic diversity directly through a combination of isozyme analysis and common garden testing to ensure that the genetic variance is not being reduced for sets of selectively neutral and adaptive traits. Reference populations must be sampled as well as populations that may be impacted by forestry practices or other human induced stressors.

Indicator 2 (Seed transfer):

The species of interest for this indicator are only those that are planted in the study area. Determine: Which species are planted? Where does the seed come from? Is it genetically improved? Are plantations of improved trees established adjacent to natural populations of the same species? Are scientifically sound seed transfer rules or breeding zones utilized? Have previously isolated populations been brought together through planting?

Indicator 3 (Selection)

Considerations in determining whether or not directional gene frequency change may be occurring in a species as a result of forestry practices:

a) Does the cutting practice suit the silvics of the species; eg. does the predominant harvest method provide for the shade conditions required by the species?

b) Is the species selectively harvested and, if so, how? E.g. do all trees reach reproductive age before being harvested? Does the selective harvesting have the potential to change gene frequencies?

c) If the species is normally regenerated after fire, is there potential for directional gene frequency change occurring as a result of fire suppression?

Among those species that are known or suspected to be susceptible to directional genetic change as a result of forest practices, choose several representing different impacts. For example, the assessor might choose one species that is being selectively harvested throughout much of the study area, one species of little commercial value that is commonly associated with the harvested species, and one species that does not respond well to the prevalent harvesting practices.

Monitoring may be carried out at different levels of intensity. The simplist level is determining whether there are adequate unmanaged reserves of each species in the study area. The second level involves establishing sample plots in the target areas and in reference areas where forestry interventions are not occurring, and monitoring the natural regeneration for phenotypic traits that would be expected to show effects of directional gene frequency change as a result of forest harvest. Monitoring would be long term. A more labor intensive method that would provide better genetic information would involve collecting seed from the remaining seed trees in a random sample of areas where the target harvesting practices occurred, as well as from reference areas. Progeny tests would be established in common environments, designed to evaluate genetic effects of the harvesting practices.

Conclusion

Genetic diversity must be maintained to ensure sustainable forests over the long term. The measurement of genetic diversity directly is difficult and costly; the choice of species to monitor and best tools to employ is not always clear. At best only a few populations of a handful of species could be monitored directly for genetic diversity measures. If such monitoring is possible, it should be concentrated on those species known to be in trouble. In general, developing and monitoring indicators to track ecological processes that maintain genetic diversity is more cost effective and may be more meaningful than monitoring direct genetic diversity measures.

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J.D. Irving Limited: actively managing for the conservation of biodiversity

Joe Gushue

Biodiversity means many different things to many different people. The concept of biodiversity can range as small as the genetic material in a bryophyte, to as big as the inter-relationships of plants and animals in an ecosystem. What I will brief you on in the next half an hour is some of the ways J.D. Irving Limited is actively managing for the conservation of biodiversity on both its freehold land and the publicly owned land that it manages.

In 1991, a research project was established in New Brunswick to provide ecosystem-based research, and science support necessary to manage a sustainable landscape. This initiative is known as The Greater Fundy Ecosystem Research Project (GFE). Since the establishment of the Fundy Model Forest in 1992. The GFE research group has worked within the Fundy Model Forest Partnership. The work that has been done by the Fundy Model Forest partners, since 1992, has contributed greatly to the approach our company is taking on setting planning objectives, and to the modifications our company has made to our Maritime operations in order to achieve sustainable native biodiversity.

Today, we have heard plenty about biodiversity. Different levels of discussion on the same issue. What I am going to focus on is Forest Management planning within the Fundy Model Forest and the implementation of Management plans in the broader context of the rest of our company's operations. I will show how we have been able to move from the concepts of biodiversity, that have been discussed over the past number of years, to the results that are evident in our woodlands operations.

I will give you a brief tour of our operations that will take us from northern New Brunswick to the Fundy Model Forest in southern New Brunswick. I will introduce our companies Best Management Practices, and finally I will describe the process we use to deliver the results. I will show you the extent of the land that we manage in New Brunswick.

We will look into our strategic level management plans. I will discuss sustainability in relation to

current events. Then I will spend some time with the Sussex freehold management plan. This plan is for the land within the Fundy Model Forest.

J.D. Irving Limited manages 600,000 hectares of freehold land and close to an additional one million hectares of publicly owned land in New Brunswick. We have five management units or Districts in New Brunswick. Each District delivers the management plans for their respective area. These areas are;

Black Brook District: freehold land in northern New Brunswick.
Deersdale District: freehold land in west/central New Brunswick.
Chipman/Miramichi District: public land in central New Brunswick.
St. George District: primarily public land in southwestern New Brunswick.
Sussex District: a combination of public and private land in southern New Brunswick.

Our strategic level management plans are spatial which means that all the areas to be operated during the next 25 years are already blocked and identified on the maps in our plan.
Our 25-year plans outline strategies for wildlife habitat, water quality, biodiversity, unique areas, and timber harvesting. In addition, our management plans forcast habitat and timber supply for 80 years.

Perhaps the most significant point to make about these plans is that they are revisited every five years. This means that there is continuing opportunity every five years to incorporate new objectives and new initiatives into our strategic plans. Such is the case with our Sussex freehold plan currently underway and the objectives that have been established through the work of the partners in Fundy Model Forest.

It is from our 25-year management plan that we develop our tactical operating plans. Operating plans are developed each year for the upcoming year. They are very detailed and provide operations staff with the information they need to meet site level objectives.

J.D. Irving Limited is committed to sustainability. It is our company's commitment and challenge to use and manage our forests today, while protecting and maintaining them for future generations. As part of this commitment, our company acts in the best interest of the people and communities in which we work. Our company is helping to advance the cause of environmental protection, and to minimize environmental damage wherever we operate.

Our company is committed to continue to invest in research. To educate employees about environmental issues and company policies. J.D. Irving is presently involved and will continue to help efforts to raise public awareness about environmental issues. These are our policies involving environmental sustainability. They are also the kinds of issues that we have asked a third party to audit throughout our company's operations. This process is currently underway.

The first stop in this process was at our Black Brook District. As recently as last month our company earned distinction there as having a "Certified well-managed forest." Black Brook was granted certification following four years of intensive review and work by the staff of Black Brook to improve forest management. Some of the improvements that have been made are consistent with the guidelines that were developed to protect native biodiversity by the Greater Fundy Ecosystem Research Group and the Fundy Model Forest.

The evaluation consisted of a review of management plans as well as on-site audits to determine performance in three areas: Timber sustainability; Forest ecosystem maintenance; and Financial and socio-economic benefits to surrounding communities.

Meeting certification standards hasn't been easy. It has been an intensive learning process, and our company has made significant changes to policy and to on-site practices throughout our Districts. The Black Brook District represents the first step to having all of our Districts evaluated by the year 2000.

The next 25-year management plan up for its five year revision is the Sussex Freehold plan. This is the freehold landbase which is a part of the Fundy Model Forest. This particular plan is the first of its kind to attempt to incorporate community based planning objectives in the context of the Ecological Land Classification system.

The freehold land contained within the Fundy Model Forest crosses the boundaries of five different ecoregions. The Grand Lake ecoregion, the Eastern Lowlands ecoregion, the Continental Lowlands ecoregion, the Southern Uplands ecoregion, and the Fundy Coastal ecoregion. Apparent is that the "green land" that is managed by J.D. Irving Limited represents just a fraction of the land within each ecoregion. The balance of the land is owned by many different people.

Objectives for the 1998 Sussex freehold plan will be based on five different community types. They are conifers, pines, mixedwoods, cedar, and hardwoods. Not to belabor the point, but I want to make sure that I make the point. Each ecoregion will have an objective for each of the five community types, and there are five different ecoregions. So almost overnight with the help of the Fundy Model Forest we have multiplied the degree of detail that we are using during our modeling and planning phase in order to better reflect the conditions of each ecological unit.

Let me illustrate the process we will be using to set our objectives. First, we are utilizing the data that Dr. Forbes, from the University of New Brunswick, and company, have made available regarding the forest conditions pre-dating European settlement. Second, we have the present condition of our forest, which can be used as a benchmark to monitor the effects of our objectives. Finally, we will be incorporating the community-based objectives into our model. The results of this modeling phase will yield the impact this approach has on resource supply. The so-called first run is a projection that was done prior to spatial blocking. I expect to deliver our final projections in the near future.

To give you a better understanding I will profile each ecoregion begining with the Eastern Lowlands. The Eastern Lowlands is presently characterized as having 50% conifer, 30% mixedwood, 10% pine, with a little cedar, and pure hardwood. The pre-settlement data would indicate a similar condition with more conifer types, and fewer mixedwood types than at present.

The proportion of communities, in the Continental Lowlands, is distinctly different to the proportion of communities in the previous slide of the Eastern Lowlands. This point is also apparent in the last three ecoregions.

Red spruce is very prevalent in the Fundy Coastal ecoregion, and therefore will dominate the management strategies used there.

The Grand Lake ecoregion is currently characterized by a high component of mixedwood and a significantly low level of cedar. This presents an opportunity to manage cedar, in this ecoregion under a special status. This is just a quick example of the challenges that exist when planning at this level.

Since our land represents only a portion of each ecoregion, any work that we do to manage within each unit can only be successful to the extent of our land. To truly meet an objective within an ecological unit there must be a concerted effort on behalf of all the landowners. This concept is not new to the partners of the Fundy Model Forest. There is a potential to balance community objectives across ownership boundaries.

I want to show you some images that I put together from locations throughout our Districts. The first set of images will illustrate some of the landscape indicators that we are currently managing for. Some of the concepts surrounding these tour stops are not new to the partners of the Fundy Model Forest.

If stand replacement is the appropriate prescription, then patch size must be carefully selected. Currently on our freehold land, patches range up to 60 hectares in size. The average patch size is around 25 hectares. In many stands, however, like the red spruce stands in the Fundy Coastal ecoregion, individual tree selection is a more appropriate prescription.

Travel corridors provide a means for plant and animal material to move throughout the landscape. By maintaining these corridors and by varying patch sizes and their distribution, we are ensuring a continued flow of genetic material.

As a way of managing for the conservation of these travel corridors, our company surpasses Provincial regulations and maintains 60 meters on each side of all mapped watercourses. The result is a network, which

connects the landscape.

An underlying strategy that has been part of our planning process is the maintenance of older age classes. Currently we have objectives to maintain old age classes in all community types.

An uneven-aged management strategy in hardwood types will ensure old trees remain as a stand component.

Maintaining old mixedwood stands is important for the species that rely on this condition.

Our company's seed orchard in Parkindale is central to maintaining a successful tree improvement program. Seed source and nursery stock quality are keys to the success of a forest plantation and play a role in maintaining genetic diversity. The objective of our program is to produce broadly adapted, genetically improved seedlings of high quality and good health for planting.

Species selection remains the keystone to a successful planting program. Selecting the tree species which is most suited to the planting site is one of the most critical elements governing plantation success.

Currently our staff are developing practices which will ensure that our plantations also contain a significant level of structural and compositional diversity as that of the natural forest.

Setting landscape level objectives for maintaining community types is just the start of the process. It is essential that employees recognize when they are in a position to influence covertypes.

Sufficient training and development helps ensure that crop trees are selected based upon suitability to on-site conditions, future value and biodiversity objectives.

An efficient transportation system is necessary to protect forest resources and water quality effectively. Properly located and constructed roads will provide safety and minimize environmental impacts. Our systems are being designed to minimize the amount of land which is converted to roads. The technology being used for the off-road transportation of wood products is always under review. For example, by changing our harvesting system from skidders to forwarders we are able to significantly reduce amount of road and the number of stream crossings that are necessary.

Our company has recognized the importance of having areas set aside for research into the management for ecosystems and the conservation of native biodiversity. In fact our company has established a network of protected management benchmark reserves.

In addition to this effort, our company is structuring a formal research effort with an external advisory committee to address information and technology gaps relative to ecosystem, habitat and wildlife management.

J.D. Irving Limited has initiated a Unique Areas Program. Over the past several years people have been identifying unique areas within our woodlands. Presently there are over 270 such sites.

Our staff have collected detailed information including vegetation surveys, photographs and any special recommendations for these areas. Each of the areas in this expanding program is catalogued on our Geographic Information System to ensure forest management operations do not impact on their integrity.

Areas with special ecological, historical, geological, scenic or recreational significance are included in this program.

In addition to the scientific benchmark reserves and the areas protected in the Unique Areas program, there are a number of other areas that have been identified by the partners of the Fundy Model Forest during a Gap Analysis project. These too have been incorporated into our strategic level planning.

Riparian zones are practical areas that protect water quality. These zones shade the brook, keeping the water temperature cool.

Riparian zones protect against the erosion of streamside banks.
They act as filters, absorbing nutrients before they enter the stream. They also supply a source of coarse woody debris for the stream. In an effort to ensure that these traits are maintained, we have expanded our buffer strips from 30 meters to 60 meters on both sides of the brook.

I will now illustrate some of the Site Level indicators that we are actively managing.

Provincial biologists, as well as our own Foresters have identified many areas that are important in the spring for moose to calf. Typically they have a dense overstory adjacent to standing water on a bogland. These areas are ribboned off and protected for this value.

Deer wintering areas have been identified by wildlife biologists. These deer yards were expanded to include sufficient area so that strategic management would ensure a continuous habitat supply.

Within these Deer wintering area management units the objective is to maintain a long-term supply of critical winter or moderate winter habitat. Typically these units range from a few hundred hectares to three thousand hectares.

In 1997 as an objective in the Public land Management plans, 10% of the public land that we manage was identified as mature coniferous forest habitat.

The criteria for the selection of this area was largely based on the American Pine Marten. The Pine Marten is used as an indicator species for many other species of wildlife which rely on similar types of habitat. The objective within this area is the long- term supply of mature coniferous habitat.

In some cases some tree species are reduced in abundance and distribution. A good example of this is Eastern White Cedar in the Grand Lake Ecoregion. In this case special attention is given to ensure that the species is not further reduced. Operationally we identify them as legacy trees and select them to remain following harvest. This is the case even in an area that will be site prepared and planted.

By far the single largest change that our company has recently made, which has made a significant impact on regenerating areas, was the move away from full tree skidding to a cut-to-length harvest system and short wood forwarding. The result is that all of the biomass, other than the useable forest products, remains scattered throughout the site. Where cut-to-length is not possible, a process is in place to scatter the branches back over the site.

As a result of the structural impact that stand-replacing harvesting is having, our company has recently adopted guidelines to use during our operations.

The result of this initiative is that snags and cavity trees are incorporated into the new regenerating stand. Even those stands which will be site prepared and planted.

Wherever possible, snags, cavity trees or legacy trees will be managed in the form of a clump of trees. We believe that this consolidation of material will provide even more opportunity for site specific habitat.

Snags, cavity trees, legacy trees, clumps, islands, and organically shaped harvest areas provide and will continue to provide a level of vertical structure and native biodiversity that would otherwise have been lost.

You have seen some images and some explanation as to the biodiversity that's been incorporated into our strategic and our operational plans. What I want to show you is what we think is at the center of our management system. Our Best Management Practices and our Internal audit process.

We have developed a set of Best Management Practices (BMPÆs) that is being used as a basis for decision-making in the field. Our set includes a BMP for:

harvesting operations
maintaining biodiversity and wildlife habitat
road construction
watercourse crossings
reforestation
nurseries and seed orchards
precommercial thinning, and
pesticide use in forest management.

The following example is our BMP for maintaining biodiversity and wildlife habitat.

The goal of all our Best management practices is to manage the forest with work methods that are reasonable, achievable, and cost effective.

The impact of forest management practices on many forest species is unknown. Certain harvesting scenarios that benefit some species will often affect others. The greater the degree that managed forests resemble the forests that were established from natural disturbances, the greater the probability that native species and ecological processes will be maintained. Some species and habitats known to be at risk or regionally important will require special management efforts. Conserving biodiversity and managing wildlife habitat should proceed on the basis of the best knowledge available. Our approaches can be refined with the development of new information.

Our objective is to move towards an ecosystem-based management approach.

Our practices include:

A variety of patch sizes

A component of older forest types

Maintain a minor species component during selective harvesting

Identify and manage connective corridors, And retain wildlife trees.

I will demonstrate our process of adaptive management. The underlying premise is that things that get measured get done. We call it our IQ200 system. The IQ stands for Irving Quality and the 200 represents the number of points available.

The IQ200 system promotes continuous improvement. It applies to all of our operations. It is in the form of a competition within and among districts. There are awards for high quality performance, which tends to encourage positive actions.

One component of our IQ200 system is the provision for a sustainable forest management field audit. The audit is designed for harvesting, silviculture, and road operations. The internal audit team is selected from key senior staff with a strong background in operations.

The system that we are currently using in Sussex is a series of positive statements about key performance indicators. There is a set of questions in each of the three categories of prescription, practices, and people.

The following is an example of a sustainable forest management audit for harvesting operations

Statement #2 - Wildlife habitat concerns were adequately addressed in and around the block.

Statement #2 - Stream siltation is not/will not occur to any significant level as a result of our operations.

Statement #1 - There is no indication of oil/fuel spillage on the site.

Statement #4- This block exemplifies that our sustainable forest management system is working well, and I would be proud to show it to anyone.

So thatÆs how it can work. If it can be measured it can get done.

Planning an activity and making sure that it gets implemented as planned is at the center of our IQ200 system.

I think that if we know what we want to conserve, then we can take action to conserve it.

Session Three:

A 30 minute plenary discussion occurred with the invited speakers for questions, discussions and identification of opportunities for cooperation or identification of potential new Strategic Initiatives and projects that can be considered by the Local Level Indicators Working Group in the development of future work plans

Aboriginal Perspectives on Wildlife Inventories and Traditional Ecological Knowledge

Ruth Ogilvie and Barbara Beasley

Introduction

To address First Nations' perspectives and interests in sustainable ecosystem management within Clayoquot Sound, the Clayoquot Scientific Panel (1995) presented a set of recommendations including:

Standards for forest practices must incorporate traditional ecological knowledge. Conflicts between scientific knowledge and traditional ecological knowledge must be resolved in consultation with the Nuu-Chah-Nulth of Clayoqouot Sound. Inventory, monitoring and research must also recognize and include TEK.

Planning inventories undertaken in Clayoquot Sound for ecosystem management must be done in full consultation with and full participation of the Nuu-Chah-Nulth of Clayoquot Sound. Nuu-Chah-Nulth cultural resources and culturally important areas must be incorporated in planning inventories before completion of the planning process.

All ongoing ecosystem management activities must incorporate monitoring programs for impacts on biodiversity, soil, water quality, fisheries and marine systems, and cultural sites, with full consultation and participation by the Nuu-Chah-Nulth of Clayoquot Sound.

Recommendations pertaining to First Nation's perspectives along with recommendations for silviculture, harvest, transportation, tourism/recreation and sustainable ecosystem planning and monitoring within Clayoquot Sound were adopted by the government of British Columbia and have been at various stages of implementation over the past 3 years. The Long Beach Model Forest Society has been involved in several projects to advance these recommendations. This paper reports on an ongoing project to learn about First Nations' values and traditional knowledge related to wildlife species and conservation in Clayoquot Sound. We acknowledge the financial support provided by the B.C. Ministry of Environment, the Federal Student Work Experience Program and the Long Beach Model Forest Society, and, most importantly, the generous sharing of knowledge and views by the Nuu-Chah-Nulth people who have participated in the study to-date.

Our study has the following objectives:

To identify species of importance to Nuu-Chah-Nulth that have not and are not being studied by western scientists as part of the baseline information being gathered for forest planning in Clayoquot Sound.

To document Nuu-Chah-Nulth impressions of changes in wildlife population sizes and distribution in locations that were familiar/important.

To document Nuu-Chah-Nulth ideas and impressions about causes of declines/changes in distributions of wildlife populations.

To document Nuu-Chah-Nulth ideas about how wildlife populations can be protected from further decline.

To identify Nuu-Chah-Nulth attitudes about sharing their perspectives, values, and traditional ecological knowledge.

To gain suggestions for how to incorporate Nuu-Chah-Nulth perspectives and traditional ecological knowledge into forest management.

Methods

We adopted the Draft Protocols for Researchers that were developed by the Traditional Ecological Knowledge Working Group comprised of elders and other knowledgeable people from within the Long Beach Model Forest area. The protocols were designed to promote inclusion of First Nations in western scientific research, to assist communication between researchers and communities, and to ensure that researchers provide benefits to the communities, such as copies of data and reports. In addition, for researchers investigating traditional ecological knowledge, the protocols require researchers to clearly state their intent and receive appropriate approval for their research, to train and include community members in their projects, and to respect wishes for limited or unacceptable circulation of data, especially those related to private or spiritual matters.

To date we have interviewed eight people from three different nations, Tla-o-quiaht, Ahousaht and Ucluelet. We called upon those who were recommended to us by community members as people known to have knowledge about wildlife. Ruth introduced the project in person or by telephone to determine whether people were willing to participate. Our intent was to have two researchers, Ruth and Barb, interview several people from each community together with a youth present as a witness. We asked interviewees if they had a young relative who would be interested in witnessing the interview and following up later to determine whether there are any additions or changes to be made in what was transcribed.

The interviews involved a combination of questions (Table 1) and open-ended conversation to encourage people to share their knowledge and views comfortably. We created a set of color photos of species being inventoried in case the interviewees did not know the English names of the species. We brought a map of Clayoquot Sound so that people could show us areas of land where they had observed and interacted with wildlife. Concerns and issues about intellectual property rights were discussed and people were assured that information from the interview would not be shared without their approval. We developed a letter of consent to be signed after people reviewed the transcripts.

Table 1. Interview Questions

Were these species traditionally used as a food source, as clothing or in spiritual activities? Show photos of each species and ask for the Nuu-chah-nulth name or word for each.
Are these species used in the same way today?
Are there any creation stories or legends you would like to share?
Have you noticed a change in the numbers (population sizes or distributions) of each of these species? Refer to the map. What do you feel caused these changes?
Can you suggest ways of conserving these wildlife species?
Are there any other species that have changed in numbers or distribution that you would like to see studied, or that you would like to discuss today?
Have you ever spent time with a scientist? If yes, how was that time spent and how did you feel about the interaction between the scientist and yourself?
Do you think its a good idea to combine our traditional knowledge with western science to make management decisions? Do you have ideas about how can this be done?

Our Findings To-Date

In response to our questions about species that were traditionally important to Nuu-Chah-Nulth, people told us that deer, elk, ducks, seabird eggs, sometimes bears, and occasionally herons were used for food. We didn't include marine animals in our set of photos, but many people talked

about the importance of fish, seals, whales, urchins, chitons, herring eggs, etc. Deer, elk, mink, otters and racoons were used for clothing, feathers, especially from eagles, were used in ceremonial dress, and deer and elk were used for making drums. Many animals (especially bears, raven, deer, mink and eagles) were featured in stories told to children to teach lessons about how to behave, e.g., to have respect, to be yourself, to share what you have. Many traditional songs and dances are about animals and peoples' connections with them. One of the elders showed us her beadwork which depicts intricate scenes of wildlife interactions, e.g., eagles feeding on fish disturbed by an orca. Everyone we interviewed described the importance of having respect for all life forms, no matter how ôuseful in terms of food or clothing, or how small. Several people emphasized the importance of being taught to take only what was needed, of not being wasteful, and of praying and giving thanks to the creator.

In response to our questions about whether population sizes and distributions have changed and why, we heard a mixture of answers. Some answers described trends that have been documented by western science, and others did not. Most people noted a large decline in deer, elk and salmon populations. They blamed this on overharvesting, an influx of too many people in the area, and ônot abiding by the laws of the land. Most people commented on the shift in the distribution of bears and cougars from the mountains to human settlements. This was attributed to human garbage and habitat destruction. One elder described a drastic reduction in the amount of eggs found in sea urchins harvested at a site near the outflow of a logged river. Another elder noted a decline in the number of small birds. A few people were able to point to the exact locations of traditionally rich fishing and hunting areas on the map.

Most of the interviewees spoke about controlling harvest levels in response to our question about how to conserve wildlife. One person explained that people have clearly shown that they cannot manage the natural resources, instead, people need to manage their own activity and keep a firm account of what is done and how it impacts on all aspects of the environment at the local level. The need for building capacity among Nuu-Chah-Nulth so that they can be actively involved in planning and monitoring was emphasized, as well as, the need to restore confidence and respect in people with traditional knowledge, such as the hereditary chiefs, who would be able to identify culturally important sites for protection at levels defined by Nuu-Chah-Nulth. Several people discussed the importance of teaching youth and adults about having respect for all living things. Education programs that involve learning traditional values and attitudes through experience with elders and interaction with the land were suggested.

All of the people interviewed expressed a willingness to share their views and knowledge. They were pleased with the protocols and approaches that we took. One band council requested that no interviews be conducted until council has more time to consider the study.

We are committed to continuing the project in anticipation of many benefits. We are gaining a balanced view of the values associated with wildlife in Clayoquot Sound that will be useful in developing criteria and indicators for biodiversity and ecological integrity. We are maintaining respectful relationships between First Nations and western scientists that hopefully will lead to strong working relationships in the future. Choo.

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Policy and Policy Development on Conservation of Biodiversity

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Summary

Canada's greatest weakness in addressing forest biodiversity policy is in developing transparent methods for collecting, maintaining, and disseminating information. This impedes effective landscape-level planning processes, making it nearly impossible to evaluate trade-offs among the different values provided by forests.

Introduction

As is true for other global environmental issues - climate change, ozone depletion, persistent organic pollutants, to name a few - concern about biodiversity conservation has been driven by the scientific community. Recent extinction rates are 100 to 1000 times their pre-human levels in taxonomically diverse groups from widely different environments (Pimm et al. 1995). Species losses threatens long-term ecosystem productivity and stability (McGrady-Steed et al. 1997; Naeem and Li 1997). This places at risk services provided by natural ecosystems, whose value has been estimated to exceed the total value of all measured global economic activity (Constanza et al. 1997).

The major response of the policy community to this "biodiversity crisis" was the negotiation of a Convention on Biological Diversity, which was completed at the 1992 Earth Summit. But this agreement does not provide solutions - it merely provides a formal umbrella for searching for them. And this remains a formidable challenge. Conserving biodiversity is perceived as meaning loss of timber production, conflicts between industry and conservation groups, difficult political choices. It is often forgotten that conserving genetic diversity is the ultimate basis for forestry's capacity to adapt to economic as well as environmental change.

Is biodiversity policy leading to on-the-ground changes, or is it creating the impression of action while postponing difficult decisions? In this paper I describe some of legal/policy agreements that address forest biodiversity issues. Biodiversity policy discussions have led to some useful conclusions, in my view. But translating these into operational forestry is proving a slow process. Although my main focus is on international policy, I will try to highlight some conclusions I believe are useful to management-level forestry in Canada.

Trade and biodiversity

At least three international agreements that deal with trade and forest biodiversity predate the Convention on Biological Diversity. The oldest of these is the International Plant Protection Convention (IPPC), which came into force in 1952. Its intent is "securing common and effective action to prevent the introduction and spread of pests and diseases of plants". The philosophy of the IPPC can be summed up in the old adage, "an ounce of prevention is worth a pound of cure". But is the IPPC doing its job?

Scientists generally regard invasive exotic species as the second leading threat to biodiversity next to habitat loss. North American forests are particularly vulnerable to invasions of European insects, which often out-compete their North American counterparts, especially in disturbed and fragmented forests. Over 300 species of tree-feeding insects from Europe have successfully invaded North America, compared to only 34 that have made the reverse journey (Niemela and Mattson 1996). Many introduced species are causing serious damage to Canadian forests (Table 1a/b). Introduced fungal pathogens are also major pests, causing large declines in chestnut, elm, butternut, and beech populations (Table 1c).

The IPPC has not slowed the rate of pest introduction. As trade with Pacific Rim nations grows, scientists warn of a new onslaught of species such as the Asian long-horned beetle, which was the target of recent

eradication campaigns after becoming established in urban forests of Chicago and New York City. Wooden packing materials are the major source of exotic bark and wood-boring species, which continue to establish and accumulate in the forests of Canada. (Humble et al. 1998). It is hard to persuade policy makers that action is needed on these issues: that risks to forestry of exotic species deserve the same level of attention as risks to agriculture.

The Convention on Trade of Endangered Species (CITES) came into force in 1975. Its intent is the "protection of certain species of wild fauna and flora against overexploitation through international trade". Depending on the degree of risk to a species, CITES can either impose a total ban on commercial trade, or can require a permit indicating that the species was obtained legally and in a manner not jeopardizing its long-term survival. Twenty-three timber species (nearly all from the tropics) are listed by CITES, although there is little or no trade in about half of these. Countries attempt to reach consensus on listing based on scientific evidence, but efforts to list commercially important species can be controversial. Listing proposals for big-leaf mahogany, for example, were narrowly defeated at the past two CITES meetings.

Despite some high-profile successes for species such as African elephants, the overall record of CITES is mixed. A recent study funded by the Netherlands indicates that about 250 additional timber species might be considered candidates for listing. Given the difficulty of correctly identifying these species from wood samples, it seems unlikely that CITES in its current form will provide the solution to the problem of unsustainable exploitation of tropical forests.

The International Tropical Timber Agreement (ITTA), which came into force in 1985, attempts to deal with tropical forest conservation in a more general way. While primarily focused on timber and trade, the 1985 version of the ITTA also contained provisions calling for "proper and effective conservation and development of tropical timber forests", and "ensuring their optimum utilization while maintaining the ecological balance... of the biosphere."

When the ITTA was renegotiated in the early 1990s there was much discussion of a pledge "to achieve exports of tropical timber products from sustainably managed sources by the year 2000". Although this language appears in the 1994 agreement, "Target-2000" remains unfulfilled. Developing nations argued in negotiations that they should not be expected to live up to a pledge that developed nations had not yet themselves adopted. An expansion of the ITTA to cover all internationally traded timber was discussed, but ultimately rejected. The use of trade sanctions against unsustainably produced timber was also rejected during the negotiations.

Current estimates are that less than 1% of natural tropical forest is sustainably managed. Unresolved issues include insecurity of land tenure, violations of indigenous rights, corruption in forestry ministries and corporations, and ignorance of appropriate silvicultural methods.

The Convention on Biological Diversity

The Convention on Biological Diversity (CBD) came into force in 1993. It has three main objectives: i) conservation of biological diversity; ii) sustainable use of its components; and iii) equitable sharing of the benefits arising out of the utilization of genetic resources.

The CBD is only a "framework". Countries have agreed to cooperate, but have not yet enacted any binding agreements similar to the "Kyoto Protocol" under the Climate Change Convention. Indeed, the CBD says that states have "the sovereign right to exploit their own resources pursuant to their own environmental policies". This raises difficult issues. Will countries ever agree to put aside this sovereign right for a common global benefit? How can a federal state such as Canada, where the sovereign right to develop resources rests with the provinces, take effective action to implement the CBD?

Every year or two the "parties" to the CBD (member states) meet and discuss biodiversity policy issues. The fourth Conference of Parties to the CBD (COP4, May 1998) adopted a Programme of Work on Forest Biological Diversity. It has four overall objectives: implementing ecosystem approaches integrating conservation and sustainable use of biodiversity, analysis of influences of human activities on forest biodiversity and

assessment of ways to minimize/mitigate negative influences; methodologies for elaboration and implementation of C&I for forest biodiversity; and advancement of scientific and technical approaches.

Parties are obliged only to address those work program objectives that they feel apply in their national circumstances. COP4 debated and rejected setting up a body that would monitor progress under the forest work program, but parties will be expected to report on activities at subsequent meetings. Canada's position is that reports done for the CBD forest work program will incorporate "off-the-shelf" materials, and provinces and territories will not be required to undertake any new obligations.

A similar non-binding approach has prevailed with regard to overall implementation of the CBD in Canada. The federal, provincial, and territorial governments cooperated in preparing a Canadian Biodiversity Strategy. By April 1996, environment ministers from all these governments agreed that the Strategy would be used as a "guide to our actions". Although governments were to report within a year of Ministerial endorsement on policies, programs and actions made to implement the Strategy, to date only Quebec, British Columbia, and Alberta have issued such reports. The federal government has issued four sectoral reports to date, dealing with forestry, agricultural, wildlife, and protected areas. Canada's Auditor General observed that the modules are a valuable tool for focussing and co-ordinating activities in their respective departments and providing information on these activities to the reader. However, the usefulness of the modules is limited as they do not contain time frames, resources to be allocated, expected results or performance indicators.

With progress to date less than expectations,, it is likely that the debate on forests and biological diversity under the CBD will intensify in coming years. Forests will be the main theme for COP6 (to be held in 2002).

Efforts to frame a comprehensive forest policy

All the foregoing agreements have potential impacts on forestry, but to date there is no overarching international forestry agreement. Canada's position is that one is needed, but this view is not universally shared. In the absence of such an agreement, the international forest policy dialogue has been advanced by several regional "C&I" (criteria and indicators of sustainable forest management) processes, and by two fora sponsored by the United Nations Commission on Sustainable Development: the Intergovernmental Panel on Forests (IPF), and its successor, the Intergovernmental Forum on Forests.

The C&I processes are helping shift international forest policy from a primary focus on timber production to a recognition that forests provide multiple values. Canada is a founding member of the "Montreal Process", composed of countries with temperate and boreal forests. Canada also has a similar domestic C&I process, endorsed by the Canadian Council of Forest Ministers. The C&I processes include a number of biodiversity indicators, addressing such topics as endangered species, protected areas, forest fragmentation, species population trends, and changes in overall forest composition. But implementation is mostly at the stage of assessing our ability to report on these topics. The main task of developing effective forest biodiversity monitoring and data management systems that can detect trends has barely begun.

The Intergovernmental Forum on Forests is charged with implementation of a report issued by its predecessor, the IPF. Although the IPF report has received little attention in Canada, it does contains a surprising number of conclusions and recommendations relevant to biodiversity. Some go well beyond Canada's main domestic forest policy document, the National Forest Strategy. Most notably, the IPF report stresses a need for government agencies to provide easy public access to forest information, to make forest assessments transparent and accessible to all interested parties, to document methods used for measurement of indicators, to perform field testing of indicators, and to disseminate effectively data in the public domain. This type of language occurs in many sections throughout the report.

A commitment by government agencies in Canada to adopt an open approach to information management would represent the single most effective step in making biodiversity policy operational. Distributions of species and forest types are simply too complex and locally variable to address with top-down regulations. Technologies for data sharing and synthesis are readily available: powerful personal computers, GIS,

the Internet. The scientific community would benefit greatly from access to government data, and volunteer naturalists' groups would have a means to incorporate their observations into a wider scientific context. Industry would have greater certainty about management actions. Government planning agencies would have a solid basis for assessing timber-biodiversity trade-offs and maximizing the conservation value of protected area networks. But Canada lags far behind other nations in this key area of biodiversity/forestpolicy. Although private sector organizations can be partners in these efforts, ultimate accountability for biodiversity conservation rests with governments.

Bunnell (1998) has warned about "paralysis by complexity" in addressing biodiversity. He reminds us that the "hastily crafted" international agreements and national policies addressing biodiversity are mainly an expression of public concern about extinction, retaining future options, maintaining productive ecosystems, and maintaining economic opportunities. Asking scientists to craft elaborate and detailed definitions of biodiversity will not address these issues. Biodiversity is a value, or set of values, that must be translated into operational goals.

The most obvious way of translating biodiversity into operational goals is to incorporate information about species, forest types, growth rates, successional processes, etc. into forest planning processes. There is a broad consensus among Canada foresters that the basic planning unit should be a landscape at least 200,000 ha in area (Booth et al. 1993; Bunnell 1998; Potvin et Bélanger 1995). Within this landscape, foresters strive to maintain the composition of forest types and to imitate the age class distribution that would be created by natural disturbance regimes. Such an approach is necessary but not sufficient to conserve biodiversity. If harvesting operations do not leave snags and coarse woody debris, critical habitat for mammals, birds, and insects is lost - hence the emphasis on retention of elements of the previous stand (Clayoquot Sound Scientific Panel 1995; Freedman et al. 1994; Hansen et al. 1991). Failure to maintain old-growth forests leads to major losses of vascular (e.g. Hong et al. 1997) and non-vascular (Crites and Dale 1998) understory plants.

My point here is that landscape-level planning must seriously address the balance between timber production and biodiversity conservation. There have been some successes in this regard in British Columbia, but attempts in other parts of Canada have largely foundered for several reasons. First, relevant data either do not exist or have not been made available . Second, methods of using these data to maximize biodiversity protection for a given area of forest reserved, such as gap analysis, have not been systematically applied. Third, not all participants in consultation processes have felt that their voices were heard.

Despite numerous and repeated pledges to complete networks of forest protected areas in Canada, progress is limited. There is a broad international consensus that the main function of protected areas is to maintain biodiversity. It is also agreed that protected area networks must be designed in a systematic fashion, taking account of natural variation in forest types and landforms across entire planning regions. We need to make hard political choices about timber-conservation tradeoffs. We need a new commitment to developing, maintaining, and disseminating biodiversity databases that inform these trade-offs and maximize the full set of values derived from our forests. Canada's forest industry will be increasingly vulnerable to international pressures if we fail to act.

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Table 1a. Significant forest insect pests introduced into Canada before 1930

Insect	Year introduced	Primary hosts
Larch sawfly *Pristiphora erihsonii*	1882	larches
Browntail moth *Euproctis chrysorrhea*	1902	all deciduous species
Poplar sawfly *Trichiocampus viminalis*	1904	trembling aspen, largetooth aspen, balsam poplar
Larch casebearer *Coleophora laricella*	1905	larches
Late birch leaf edgeminer *Heterarthus nemoratus*	1905	birches
Balsam woolly adelgid *Adelges piceae*	1908	balsam fir, grand fir, subalpine fir, Pacific silver fir
Satin moth *Leucoma salicis*	1920	poplars
European spruce sawfly *Glipinia hercyniae*	1922	spruces
Gypsy moth *Lymantria dispar*	1924	oaks, birches, larches, willows, basswood, Manitoba maple
European pine shoot moth *Rhyacionia buoliana*	1925	red pine, jack pine, Scots pine
Winter moth *Operophtera brumata*	1920s	oaks, maples, willows
Mountain-ash sawfly *Pristiphora geniculata*	1926	mountain-ash
Birch leafminer *Fenusa pusilla*	1929	birches

Table 1b. Significant forest insect pests introduced into Canada since 1930

Insect	Year introduced	Primary hosts
Introduced pine sawfly *Diprion similis*	1931	pines
Birch casebearer *Coleophora serratella*	1933	poplars
Spruce bud moth *Zeiraphera canadensis*	1938	spruces
European pine sawfly *Neodiprion sertifer*	1939	red pine, Scots pine
Elm leaf beetle *Pyrrhalta luteola*	1945	elms
Smaller European elm bark beetle *Scolytus multistriatus*	1946	elms
Ambermarked birch leafminer *Profenusa thomsoni*	1948	birches
Apple ermine moth *Yponomeuta malinella*	1957	apple
European pine needle midge *Contarinia baeri*	1964	red pine, Scots pine
Early birch leaf edgeminer *Messa nana*	1967	birches
Pine false webworm Acantholyda erythrocephala	1970s	pines
Pear thrips *Taeniothrips inconsequens*	1989	sugar maple, red maple
Pine shoot beetle *Tomicus piniperda*	1993	pines, spruces

Table 1c. Significant forest diseases introduced into Canada

Disease	Year introduced	Primary hosts
Dothichiza canker *Cryptodiaporthe populea*	pre-1900	poplars
Chestnut blight *Cryphonectria parasitica*	post-1904	American chestnut
White pine blister rust *Cronartium ribicola*	1910	white pine
Willow blight *Venturia saliciperda*	ca. 1925	willows
Dutch elm disease *Ophistoma ulmi*	1944	elms
Scleroderris canker (European race) *Gremmeniella abietina*	1978	pines
European larch canker *Lachnellula willkommii*	1980	larches
Beech bark disease *Nectria coccinea var. faginata*	1980	American beech
Beech scale *Cryptococcus fagisuga*	1980	American beech
Butternut canker *Sirococcus clavigignenti*	1991	butternut

Note: Dates of introductions need to be verified.

PUBLIC AWARENESS AND UNDERSTANDING OF BIODIVERSITY: THE CANADIAN BIODIVERSITY INSTITUTE EXPERIENCE

Heather Hamilton

I was here on Friday to hear the reports from all the Model Forests and the discussion afterwards was particularly interesting to me. If you recall, the group was identifying some challenges, barriers and gaps, particularly in the lack of systematic and taxonomic human resources and information, and some Model Forests (Barb Beasley from Long Beach Model Forest) expressed the frustration about so much to do and so few resources, especially knowledgeable volunteers to be able to carry out the biodiversity inventory and monitoring projects that have been developed. I wanted to jump up and suggest that maybe I should give my presentation then and there because it was so pertinent to what was being said.
However, I kept my mouth shut, knowing that everyone was anxious to finish up and hoping that you would all still remember that discussion this morning.

Basically, I've been asked to describe to you the Canadian Biodiversity Institute's programmes and how we deal with public awareness of biodiversity issues. But, before I do that, I'd like to give you some of the background that informs our thinking and philosophy.
One of the documents that I have come into contact with recently is the UK National Biodiversity Strategy, and one quote from the strategy caught my eye when I was preparing this presentation. It says: "There is an urgent need to re-establish contact between people and nature at first-hand, ...to encourage direct knowledge and experience of biodiversity on an everyday basis. This should lead to a greater sense of responsibility and direct involvement in environmental issues." Simply put, what we'd say at CBI is that awareness leads to understanding, leads to caring, leads to action.

Our goals at the CBI are to: 1) educate Canadians for increased public awareness and action around the conservation of biodiversity and 2) to develop community-based programmes for the preservation of ecosystems and biodiversity. Generally speaking, we want to bring the science end of biodiversity together with public action. We want to increase the level of biodiversity and taxonomic literacy in a manner that is both fun and relevant for both the public and the scientist.

The public is ready for this (I'm not sure many of the scientists are, but that's another issue). There is an appetite among people to know about other species and how ecosystems work and, more importantly, to be able to develop their own skills to identify species and help monitor habitats. Relatively speaking, Canadians are quite well educated on environmental issues - over the last 30-40 years we've done a pretty good job of raising awareness on the environment. The next step in the process now is facilitating personal action. People are keen to become involved and to contribute directly if they are offered something tangible and worthwhile to do. I was interested to read in another section of the UK Strategy, where it specifically points out the value of an involved and educated public in contributing to the country's success with biodiversity inventories and monitoring: "The UK is fortunate in still possessing a significant number of individuals who contribute vital data as a result of their enthusiasm for nature." In Canada, unfortunately we can't yet say this, but momentum is building and I hope before too long we can also confidently make that kind statement.

Currently, volunteers can and are playing an increasingly important role in monitoring biodiversity. We are all aware of the numerous international, national and regional volunteer-based monitoring programmes such as the Breeding Bird Survey, Feederwatch, the Marsh Monitoring Programme, Frog Watch, etc. Of necessity, we must rely on these types of volunteer-based programmes to provide the majority of our locally-gathered biodiversity information and that's not a bad thing.

Notwithstanding these and other existing programmes however, I think our volunteer-based capacity in Canada, in relation to biodiversity issues in particular, is very much underdeveloped and underutilized. Over the next few years we should be aiming our efforts towards exponentially increasing that participation in both existing and new programmes. To do this, we have to train others in the skills and knowledge needed to be reliable, on-the-ground biodiversity observers and watchdogs. We need to both demystify and democratize the science of biodiversity (I'm speaking about taxonomy, systematics and ecology) and involve the public in action-oriented programmes that give people first-hand knowledge, skills and the opportunity to actively participate in collecting, analyzing and utilizing information on local level biodiversity. To quote from a new publication from Environment Canada, called ***Learning About Biodiversity, A First Look at the Theory and Practice of Biodiversity Education, Awareness and Training in Canada,*** "We must bridge the gap between expert and amateur enthusiast when it comes to building capacity in biodiversity data collection. Developing educational (and

I would add training) programmes in which scientists and members of the lay public work cooperatively to ensure that data is scientifically valid and accessible contributes to the goals of the (Biodiversity) Convention on a number of important levels." I would also add that it can contribute substantially to our ability to make properly informed and environmentally sustainable decisions at the local level and that's important because it's at the local level that biodiversity is ultimately lost or saved. If we can create a legion of trained, knowledgeable amateurs who can significantly expand our ability to inventory and monitor biodiversity we can make a substantial contribution to our national "biodiversity information index".

(Another benefit of creating a legion of people who understand and appreciate biodiversity, is that those of you working in an official capacity to achieve important sustainable biodiversity goals have a ready-made public support system to help you achieve those goals. I would think that in a few years time when the next five-year mandate for the Model Forest runs out that this would mean a national cheering section for your work which could be very important politically.)

Of course, another valuable outcome of exposing so many more people to taxonomy first hand is that we can help raise the public profile of systematics and the specialists who work in it. Ideally we can give young people new models and mentors on whom to base their own career choices and as a result hopefully pass the torch to new generations of trained taxonomists. Given the state of taxonomy today it would be rather like rehabilitating an endangered species! I would love to see the day when young people no longer aspire to being astronauts and exploring other worlds - instead they will want to explore universes here on Earth through systematics!

I think the Model Forest system, with its mandate, structures, goals for biodiversity conservation and developing sustainable forestry practices, and the history of public consultation is an ideal vehicle to help achieve this goal. From what I have been hearing and from my own experience with the Eastern Ontario Model Forest (EOMF), Model Forests seem to be pretty good at involving the public in consultation processes and I would encourage you to continue that involvement with the actual implementation of inventory and monitoring programmes. The EOMF, which is a supporting and active partner in some of CBI's programmes, has recognized the potential of this approach, perhaps because of its specific demographic nature - i.e. a large population base and 88% of the land base in private ownership - which makes this kind of approach both feasible and attractive. Each Model Forest is different, but all of you have some population base and are probably associated with institutions such as universities, government agencies and departments, National and Provincial Parks and museums in your jurisdictions which can provide valuable taxonomic expertise and information. In addition, First Nations can offer valuable expertise, for example in the identification of medicinal plants.

When I was here on Friday, I heard that most of the Model Forests have identified, at least at a preliminary level, their Criteria and Indicators, including those for biodiversity. I also heard that it will be difficult for the various Model Forests to actually get all the things done in the inventory and monitoring area that need to be done. My recommendation would be that some time should be spent in identifying the taxonomic human resources in your mandate areas, and developing volunteer training programmes and activities, whether through partnerships with engos and others or within your own structures, that will then give you a long-term volunteer capacity to collect biodiversity information. This is exactly the type of project in which we are currently partnering with the EOMF and the Eastern Ontario Biodiversity Museum. We call it the Eastern Ontario Natural History Observer Network.

The goal of this project is to create a volunteer network that will systematically and comprehensively inventory and monitor aspects of biodiversity, climate phenomena and sustainability in Eastern Ontario to provide reliable data with professional analysis and interpretation on a long term basis. The network will include individual volunteers as well as organizations and it will be active in wild, rural and urban areas. The geographical range that we cover includes the core area for the Eastern Ontario Model Forest, and extends through the corridor from the Adirondacks in New York State to Algonquin Park, and including parts of western Quebec.

Network volunteers will be trained and certified to provide information on a specific list of indicators (both phenomenon and taxa) developed through consultations with the volunteers themselves as well as a number of agencies and experts. We have an expert Advisory Committee set up to help develop our lists and procedures. They will be backed up by a roster of specialists in taxonomy and other areas. We're fortunate in this area of Eastern Ontario to have many retired as well as still actively employed specialists who are willing to support this programme. Recognized existing protocols will be used for observations of some of the indicators, and where they do not exist we will try to develop appropriate protocols. A database has been established at the EOBM to accommodate the network.

Observers will be divided into categories depending on the level of involvement they desire. Some volunteers may elect to monitor only a few phenomena or taxa at certain times of the year, while others may choose to be more heavily involved with daily, weekly or monthly observations on a number of indicators. It's important to be as inclusive as possible in recruiting volunteers, so criteria will be established that enables a wide range of participants such as farmers, foresters, urban and rural dwellers, children, naturalists, scientists and others to be involved.

The network will be able to offer several specific benefits, including to: 1) greatly increase the ability to inventory and monitor the geographical area under study; 2) provide a quick response capacity, for example to follow-up on natural disasters such as the infamous ice storm we experienced in January 1998, or to track a rapidly expanding invasive species such as the Asian Longhorn Beetle; 3) contribute substantially to existing monitoring programmes and fill in gaps in these programmes.

We expect that the first two years of the programme will be a pilot phase which will involve a lot of "sorting out" of reliable participants and indicators and testing the database, and this fall we are going to have a one-month pilot taking place to test out the concept. Some of the ways that the Eastern Ontario Model Forest is involved include: providing financial support; Cathy Neilsen sits on the Expert Advisory Committee; facilitating EOMF member participation as volunteers; potentially GIS mapping of the data; and, I'm sure there will be other things. The EOMF, in turn, will clearly benefit from the network in being able to accomplish some of its identified biodiversity objectives. This is a very promising and exciting project, and we are looking forward to working together on it. I'd like to thank Cathy and Brian for their support and participation. We hope that once we have a good working model up and running that the concept will be replicated in other places across Canada.

EASTERN ONTARIO BIODIVERSITY MUSEUM

Another project which started out under the aegis of CBI but which is now separately incorporated, that I have already mentioned in conjunction with the network is the Eastern Ontario Biodiversity Museum (EOBM), which will be situated near Kemptville, which is also where the EOMF is based. The EOBM is scheduled to open to the public in the spring of 1999. This will be a full service museum with exhibits, in-house and outreach programming, and collections and research. This is one of only a very few, locally-based natural history museums in Canada, and the only one in Ontario. The core of the EOBM's collection is based on parts of the Carleton University natural history collection (which was being orphaned about a year ago) as well as some private collections. With the tremendous support of the local municipality of North Grenville we are acquiring a building and will hopefully be moving the collection in in the next two months. We have an inaugural fundraising event on November 4 with Robert Bateman as the featured guest.

The EOBM will serve the same mandate area as the Model Forest for exhibits and programming, with a much larger area (the Adirondacks to Algonquin corridor) for research and collections. We see this facility as being a centre of biodiversity education, research, information and activity for the whole region and we plan to work in close partnerships with other organizations, such as the EOMF, throughout this area.

Now, many of you will probably say that this is a special kind of project that we have been able to create because of a unique sequence of events. To some extent that may be true, but I think that similar opportunities will arise around the country as other university and private collections are looking for new homes. It's a big undertaking to establish a museum, but not an impossible task. It takes imagination and determination and you need a certain penchant for risk-taking perhaps, but judging from the response we have had from the public, local government, fellow biodiversity-related organizations, etc, just about everybody in fact, the time is ripe for more of this kind of endeavour. There should be as many locally-based natural history biodiversity museums across this country as there are local history museums. Once again, I think the Model Forest concept provides a good vehicle for this kind of project. Through partnerships you could all develop your own biodiversity museums as a focal point for action and I would urge you all, if the opportunity arises to consider this as an option.

To give credit where credit is due, our own museum would not exist if not for the incredible dedication and hard work of Aleta Karstad and Fred Schueler who are the driving forces behind this project.

GREAT CANADIAN MILLENNIUM BIO-BLITZ

The next project I would like to tell you about is the first one CBI developed, called the Great Canadian Bio-Blitz, now re-named the Great Canadian Millennium Bio-Blitz. I can't take credit for originally developing the Bio-Blitz concept, that honour goes to the National Wildlife Service in Washington, D.C., where they held

the first Bio-Blitz in 1996, however, CBI has expanded the concept and turned it into a national activity here in Canada with strong public involvement.

The Bio-Blitz is an excellent tool through which to experience first hand the biodiversity in any habitat and for generating community involvement in biodiversity inventorying and monitoring. (Some of you who went on the Salamander exploration with Fred Schueler yesterday will understand the excitement people feel when they discover something for the first time and someone knowledgeable is there to tell them about it. Contacts with other species like this touch something deep within us. That's part of what the CBI's programmes hope to do.) The Bio-Blitz links local specialists in ecology, natural history and taxonomy, both scientists and expert amateurs, with the general public in an event which documents and records as many species as possible within a particular natural area in a 24-hour period. So, teams of people or individuals fan out over an area and find and record as many species as possible within the 24 hours. (To be honest, not a whole lot gets done between about 11pm and 6am, but if you have a bat, moth or other nighttime creature expert the event can really go for the full 24 hours.) This programme has good educational value as well as being scientifically useful. For example, in Ottawa the first year, we Blitzed a large public park by the Rideau River and identified over 740 species in several taxa. Among these were: a) a species of microfungi newly identified for the Western Hemisphere; b) two species of beetles that had been absent for about 30 years and had now returned to the shoreline of the river, which had not been noticed; and, c) a new lichen species was identified for Ontario and another for the Ottawa area.

The Bio-Blitz can be specifically tailored to the resources and needs of the community group involved. It can be as simple as focusing on the identification of just a handful of taxa to identifying as many species from as many taxonomic groups as possible. It depends on how many experts you have available. Blitzes can take place in a wide range of habitats from wilderness areas to urban parks. They can concentrate on one natural area or several depending on the available human resources and, for example, the need to monitor specific locations and produce inventory data to help protect them, or the need to provide data to contribute to management plans or community development planning. The same area can be inventoried each year to provide a long-term database, or new locations can be chosen each year. Bio-Blitzes can involve any age group and people with all different levels of expertise and areas of interest, and they are a great family activity, providing an opportunity for everyone to learn about biodiversity together. It's very seldom that people get a chance to go out "in the field" with taxonomic experts - the public enjoys it and the experts have fun too because they don't often get a chance to work in their own "backyards", with other taxonomic specialists or with the public in an educational context.

June is Bio-Blitz month because for most of the country, at some point during that month there is a fair amount of biodiversity in a wide range of taxa available for inventorying. The exception is, of course, southern B.C. which usually will have its blitzes earlier when their available biodiversity is at its peak. The pilot Great Canadian Bio-Blitz took place in Ottawa in June 1997, and this year several Bio-Blitzes were held throughout British Columbia and Ontario. The Suzuki Foundation held a Bio-Blitz that included the First Nations people living in the area being blitzed who focused on identifying medicinal plants and explaining how they were used. It was a great success.

"The Great Canadian Millennium Bio-Blitz" is planned to take place in June of 2000 by which time we plan to have at least 200 communities participating. I hope each of the Model Forest areas can anticipate in our Blitz in 1999 and especially in 2000. CBI has a planning manual, data sheets, and lists of taxonomic experts across the country to help participating groups organize their blitzes and we are available to answer questions and provide advice. We produce a Bio-Blitz Bulletin recording all the results of all the blitzes with the photos and narratives sent to us and this will also be on our website when that is set up sometime soon I hope.

I'll just briefly mention a few of our other projects: We have a School as Ecosystem programme which focuses on transforming schoolgrounds into areas of natural biodiversity in which we can involve both the students and others in the school community as well as inhabitants of the surrounding community in long-term inventory and monitoring projects. Our first training centre schools are currently being developed in the Ottawa-Carleton area. I would urge you not to overlook the possibilities of getting your messages across through these types of school programmes. It's easy to incorporate sustainable forestry and biodiversity messages into schoolgrounds transformation projects.

We are also working with the community of Mississippi Mills, west of Ottawa, in a community-wide greening project which I anticipate will become a prototype for developing a Local Biodiversity Action Plan (similar to those being developed in the UK). This project to-date involves components such as schoolgrounds

transformation, community mapping of natural history aspects, clean air and clean water campaigns, banning of pesticides, creating new walking trails and outdoor recreational facilities, and participation in the CBI projects mentioned above (Bio-Blitz, Observer Network and Museum). If we succeed in developing this Local Biodiversity Action Plan in Mississippi Mills, we hope that we can help to develop similar projects in other communities across Canada. Thanks are due to the EOMF also for supporting the schoolgrounds transformation aspect of this project.

One last idea I'd like to mention has come out of a recent meeting of programme review at the EOMF and a comment made here on Friday by the woman from Louisiana Pacific. At the programme review, after giving my presentation about the Observer Network, I was approached by someone from the Domtar company who asked if we could do a training session for some of their employees working in forest situations and some of their scientists to expand their knowledge of forest biodiversity, especially in being able to identify the smaller-sized taxa. A similar comment about this kind of need in the industry was made here on Friday. It makes me think that CBI should try and develop the capacity to provide taxonomic training sessions for industry and others - organize a sort of taxonomic road show with experts that could travel the country giving workshops where needed. Clearly, I have to think more about this idea but it would seem to have some merit.

So, that is a snapshot of what we're up to. I want to emphasize that I don't think there is anything that we are doing that is not easily replicable anywhere else in the country. Partnerships are what allow us to get our programmes done and that is essentially what Model Forests are all about. I hope some of you will leave here with a new enthusiasm to undertake some of these programmes yourselves. When you see how excited and interested the public and expert alike become when involved with these sorts of projects, and how much valuable data can be generated on which to base decision-making, you realize how very worthwhile and needed they are. Thank you.

References:

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